

## DOCUMENT RESUME

ED 279 874

CE 046 607

**TITLE** Heating, Air Conditioning and Refrigeration. Vocational Education Curriculum Guide. Industrial and Technical Education.

**INSTITUTION** West Virginia State Vocational Curriculum Lab., Cedar Lakes.

**PUB DATE** Feb 87

**NOTE** 153p.

**AVAILABLE FROM** West Virginia Vocational Curriculum Laboratory, Cedar Lakes Conference Center, Ripley, WV 25271.

**PUB TYPE** Guides - Classroom Use - Guides (For Teachers) (052)

**EDRS PRICE** MF01/PC07 Plus Postage.

**DESCRIPTORS** \*Air Conditioning; Air Conditioning Equipment; Behavioral Objectives; \*Competency Based Education; \*Course Content; Educational Resources; Fuel Consumption; Fuels; \*Heating; Job Skills; Lesson Plans; Postsecondary Education; \*Refrigeration; Secondary Education; State Curriculum Guides; Teaching Methods; Thermal Environment; Trade and Industrial Education; Units of Study; Ventilation; Vocational Education

**IDENTIFIERS** \*West Virginia

**ABSTRACT**

This curriculum guide contains 17 units that provides the basic curriculum components required to develop lesson plans for the heating, air conditioning, and refrigeration curriculum. The guide is not intended to be a complete, self-contained curriculum, but instead provides the teacher with a number of informational items related to the learning outcomes and allows the teacher flexibility to design instructional activities, select resources, and deliver instruction most appropriate for the learner and learning environment. The units of instruction contain the following components: learning outcomes; associated tasks; performance standards; lists of tools, equipment, resources, and limiting constraints; performance steps; and enabling objectives. The units cover the following topics: tubing, fitting, soldering, and brazing; basic compression refrigeration; domestic refrigeration; introduction to electricity; electrical components; electric motors; wiring diagrams; window air conditioners; residential and commercial air conditioning; commercial industrial air conditioning; commercial refrigeration; gas heating; oil heating; electric heating; heat pump, solar, and hydronics; dehumidifiers and humidifiers; and heat gain, heat loss, and duct design. (KC)

\*\*\*\*\*  
\* Reproductions supplied by EDRS are the best that can be made \*  
\* from the original document. \*  
\*\*\*\*\*

ED279874

# VOCATIONAL EDUCATION CURRICULUM GUIDE

## INDUSTRIAL AND TECHNICAL EDUCATION



U.S. DEPARTMENT OF EDUCATION  
Office of Educational Research and Improvement  
EDUCATIONAL RESOURCES INFORMATION  
CENTER (ERIC)

☒ This document has been reproduced as  
received from the person or organization  
originating it.

☐ Minor changes have been made to improve  
reproduction quality.

• Points of view or opinions stated in this docu-  
ment do not necessarily represent official  
DERI position or policy.

"PERMISSION TO REPRODUCE THIS  
MATERIAL HAS BEEN GRANTED BY

*R. Thomas*

TO THE EDUCATIONAL RESOURCES  
INFORMATION CENTER (ERIC)."

# HEATING, AIR CONDITIONING AND REFRIGERATION



WEST VIRGINIA VOCATIONAL CURRICULUM LABORATORY  
CEDAR LAKES CONFERENCE CENTER

WEST VIRGINIA BOARD OF EDUCATION  
EXECUTIVE OFFICES  
Charleston, West Virginia 25305

Kendall Hall, President  
Parkersburg, 1990

Audrey F. Horne, Secretary  
Wheeling, 1987

Patricia Full Hamner, Member  
Buckhannon, 1991

Paul J. Morris, Member  
Dunbar, 1989

EX OFFICIO MEMBER

Dr. Tom McNeel  
State Superintendent of Schools

Frances Seago, Vice President  
Athens, 1992

James P. Clark, Member  
St. Albans, 1986

Richard N. Schnacke, Member  
New Martinsville, 1988

N. Blaine Groves, Member  
Martinsburg, 1993

EX OFFICIO MEMBER

Dr. Thomas W. Cole, Jr.  
Chancellor, Board of Regents

Virgil Cook, Member  
Daniels, 1994

VOCATIONAL EDUCATION PROGRAMS ARE AVAILABLE WITHOUT REGARD TO RACE,  
COLOR, NATIONAL ORIGIN, SEX OR HANDICAP.

# **HEATING AIR CONDITIONING AND REFRIGERATION**

Published by:

West Virginia Department of Education  
The Bureau of Vocational, Technical and Adult Education  
Vocational Curriculum Laboratory  
Cedar Lakes Conference Center  
Ripley, West Virginia 25271

Printed  
February 1987



## Preface

The concept of competency based vocational-technical education has been supported by the Bureau of Vocational, Technical and Adult Education for a number of years. Since the early 1970's, the State has sponsored the development and dissemination of numerous competency based curricula through the State Vocational Curriculum Laboratory. With the recent development of the State Master Plan for Public Education, however, the need to move rapidly toward systemwide adoption of this instructional concept in all schools is mandated by State Board of Education Policy.

According to the State Master Plan for Public Education, all instructional programs are to be learner oriented and described in terms of high quality, measurable, student centered outcomes (learning outcomes). In essence, this policy reinforces the competency-based vocational education philosophy.

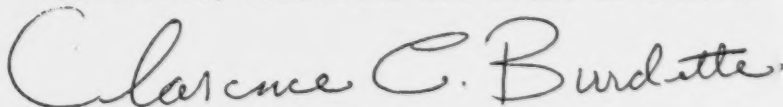
Consistent with our current efforts in encouraging the implementation of vocational education learning outcomes, we have prepared this curriculum guide to assist vocational teachers as they prepare lesson plans that are reflective of the mandated core curriculum and defensible in terms of an equitable, quality vocational program.

Additional copies of this curriculum guide may be obtained from the:

West Virginia Vocational Curriculum Laboratory  
Cedar Lakes Conference Center  
Ripley, West Virginia 25271  
Telephone: (304) 372-7021  
Toll Free: 1-800-WVA-JOBS (in state)

Any suggestions you have for improving this material may be sent to your Vocational Curriculum Laboratory. Through this feedback, we plan to continually update and revise our materials.

VOCATIONAL, TECHNICAL AND ADULT EDUCATION



Clarence E. Burdette  
Assistant State Superintendent of Schools

## Overview

The contents of this guide provide the basic curriculum components required to develop lesson plans that address the learning outcomes for this particular area of study. As such, this guide is not intended to be a complete, self-contained curriculum. Instead, the teacher is provided a number of informational items related to the learning outcomes and allowed the flexibility to design instructional activities, select resources and deliver instruction most appropriate for the learner and learning environment.

Specifically, this curriculum guide is organized in the following manner:

### Units of Instruction (Where applicable)

A unit of instruction is a group or cluster of related learning outcomes that have been placed together for their similarity or main idea of task accomplishment. An example of a Unit would be Shielded Metal Arc Welding within the welding and cutting area of study.

### Learning Outcomes

A learning outcome, oftentimes synonymous with a competency statement, is a concise description of the curriculum in terms of desired learner behavior. Such statements are measurable, may contain one or more tasks and be action oriented. All approved learning outcomes for vocational education have undergone a stringent verification process with input from teachers and representatives of the business and/or industrial sector.

The approved learning outcomes for a specific vocational education area of study represent the core competencies of what has been identified as a quality vocational education experience. They do not, however, represent the entire instructional program for any area of study. It is hoped that all vocational instructors and local educational agencies will provide learners with educational experiences that exceed the "core competencies" identified through the learning outcomes.

### Associated Tasks

A task represents an identifiable behavior that (1) has a purpose; (2) has a definite beginning and ending; (3) contains two or more steps none of which is a restatement of the original task statement if in the psychomotor domain; and (4) has a standard of performance which can be defined, described and verified. Learning outcome statements may be on the task level or may contain two or more independent tasks.

Examples of task/behavior statements are:

1. Chase external pipe threads.
2. Bleed diesel fuel system.
3. Use common standard medical abbreviations.
4. Prepare a resume.
5. Plan food experiences suitable for young children.

### Performance Standards

The Standard is defined as criteria for assessing if tasks are performed or demonstrated as either acceptable or unacceptable. The performance standard communicates to the learner the quantity and quality of how well he or she is expected to complete the task. The standard can be stated in terms such as actual percentage of achievement, the accuracy expected, the number of errors permitted, the time allowed to complete the task, the degree, or any other appropriate level at which achievement is anticipated. The standard should be based on the performance level needed on the job.

Examples of standards are:

1. The circuit board must operate within the tolerances of the circuit design.
2. The estimate must be within + or -5% of that figured by the instructor.
3. Contacts must open when more than 125% of rated current value is made to pass through the overload relay heating element or coil.
4. The installation must be complete and each conductor must be terminated according to the schematic drawing of the design.
5. The motor must carry the load without being overloaded; the directions of rotation must be correct; belt must have a deflection of between 3/8" or 1/2".

### Tools, Equipment, Resources and Situation(s)

Situation(s) is defined as the limiting constraints under which actions are to occur. The circumstances or restrictions imposed on the learner when he or she is demonstrating the behavior must be defined. Frequently, the conditions identify the testing situation used to determine learner achievement of the standard. Tools and equipment are the materials needed to perform the task being addressed in each performance standard.

### Performance Steps

Performance steps are a series of steps required to perform a psychomotor task. The steps (1) are arranged in the sequence ordinarily followed on the job, (2) have a concise start and close, (3) are limited to the accompanying task statement, and

(4) are self-supporting and do not refer to actions beyond the task performance. Performance steps developed for each task are used to determine the enabling objectives and steps and procedures for performance checklist(s) to be utilized in assessing learner mastery of the task.

### Enabling Objectives

Enabling objectives reflect the knowledges, attitudes and related skills the learner must possess in order to complete the task to the specified standard(s). As such, enabling objectives are derived from an instructional analysis of the task and/or performance steps and are stated in measurable terms of student performance.

Terms such as "define verbally," "construct," "diagram" and "list" are used to express enabling objectives, rather than obscure verbs like "know," "learn" and "understand". Examples of acceptable enabling objectives are:

1. List verbally the parts of a voltmeter.
2. Define Ohm's Law.
3. Explain relevant safety precautions and procedures.
4. Discriminate between types of life insurance policies.

Given this information for each outcome statement, the instructor is encouraged to develop the following components for lesson planning, delivery and evaluation.

### Develop Instructional Activities

Instructional activities should be designed to provide the learner with experiences related to the enabling objectives, cumulating in successful task performance. The instructional activity section of a curriculum should contain a variety of strategies designed for the learners' varying learning styles and rates.

Consideration should be given to age, ability levels, educational levels, varied learning styles, individual interests, career goals, and emotional needs when developing the instructional activities. Activities should include suggestions for large groups, small groups and individual methods. The use of small groups may help students attain the skills, knowledge and attitudes associated with each task by making them (1) feel adequate and physically competent when they lack the necessary background information and experience; (2) feel a sense of security through the reenforcement of positive group attitudes; (3) gain confidence and discover that they are an essential part



of a team engaged in the learning-teaching process; (4) learn to work without direct supervision, and (5) vary instructional routines away from lecture or other full-class methods.

### Identify Appropriate Instructional Resources

Instructional resources should be identified for each instructional activity and should be designed to help convey the message of the task and enabling objective(s). Attempts should be made to utilize modern instructional technology (i.e. television, computers, video-tapes, etc.) as much as possible in delivering the message desired. However, caution is advised in limiting the suggested resource section to only one alternative; due to the differing availability of resources between like programs across the state.

### Provide Instruction

Many misconceptions exist about how an individual teacher must manage the instructional process when utilizing the competency based approach. Oftentimes CBE is considered synonymous with individualized instruction, wherein the instructor becomes the instructional manager of the educational process instead of the more traditional view of the teacher. Such misconceptions have led many educators to renounce competency based education as a means by which the teacher loses control and direction over the instructional process and is relegated to merely a role of record keeper.

The underlying concept of competency based instruction, however, does not dictate specific instructional procedures and methodologies, but rather assures that those skills, knowledges and attitudes deemed essential for job success are taught, mastered to acceptable standards and documented. How this instruction is managed within the classroom, be it on a large group, small group or individualized basis should be left up to the instructor.

The content of the task itself and the enabling objectives dictate what should be taught. Thus, the instructional activities and supporting resources identified in the instructional plan must be designed to accommodate learner mastery of the subject matter. Where appropriate, this instruction may involve large group activities, smaller group participation and/or solely individualized study.

Where substantial diversity exists between ability and skill levels of the learners within a class, arrangements should be made to structure learning activities that accommodate this difference. This type of instructional arrangement is particularly crucial, given that one of the major premises of competency based instruction is that the learner be allowed to progress at his/her own pace and that this progression be based upon successful mastery of sequential competencies.

Also, another major consideration that must be given to providing competency-based instruction is the development of a mechanism whereby learners, due to prior experience or instruction, be allowed to "test out" on skills already attained without undue duplication of effort. This situation is most often addressed through the use of pretests prior to formal instruction.

#### \*Evaluate Learner Performance

Evaluation of learner performance is one of the most critical steps in the instructional process. Criterion-referenced evaluative measures are advocated over the traditional norm-referenced approach due to the importance of all learners being able to perform to specialized standards. As such, the evaluation of learning outcomes and their related tasks should include means of assessing learner mastery of the knowledges, attitudes, and skills outlined in the enabling objectives and regarded as essential for completion of the learning outcomes/tasks, and also, learner performance of the learning outcomes/tasks to the performance standard.

In order to adequately evaluate learners, consideration must be given to constructing testing situations that address any or all of the three domains of learning encompassed within the learning outcome or task (i.e., psychomotor, cognitive, and affective).

\*Note: The Bureau of Vocational, Technical and Adult Education is currently in the process or has developed comprehensive test item banks (written and performance) for a number of vocational education areas of study. For information relative to the availability of these item banks, contact the Assistant Director, Curriculum and Personnel Development.

#### Guide Coding System

Example:        4.2.3

- 4. - unit designation
- 2. - learning outcome under unit
- 3 - task under learning outcome



VOCATIONAL EDUCATION CURRICULUM GUIDE  
HEATING, AIR CONDITIONING AND REFRIGERATION

Table Of Contents

|                                                                                            | Page |
|--------------------------------------------------------------------------------------------|------|
| <br>Unit 1: Tubing, Fittings, Soldering and Brazing                                        |      |
| L.O.1.1. Construct a flare construction and swage joint                                    | 1    |
| 1.1.1 Construct flare joint                                                                | 1    |
| 1.1.2 Construct swage joint                                                                | 2    |
| L.O.1.2 Bend tubing to specified angles                                                    | 3    |
| L.O.1.3 Construct a condensate line                                                        | 4    |
| L.O.1.4 Set up an oxyacetylene welding station                                             | 4    |
| L.O.1.5 Light and adjust an oxaycetylene torch                                             | 5    |
| L.O.1.6 Soft solder brass and copper fittings to copper tubing                             | 6    |
| L.O.1.7 Silver braze steel and copper tubing                                               | 7    |
| L.O.1.8 Silver braze brass fitting to copper tubing                                        | 8    |
| L.O.1.9 Thread black iron pipe                                                             | 9    |
| <br>Unit 2: Basic Compression Refrigeration                                                |      |
| L.O.2.1 Sketch a basic refrigeration system                                                | 10   |
| L.O.2.2 Check for moisture in system                                                       | 10   |
| L.O.2.3 Install a filter dryer with flare and sweat fitting                                | 11   |
| L.O.2.4 Install a capillary tube in a filter dryer                                         | 12   |
| L.O.2.5 Install a liquid indicator in a liquid line                                        | 13   |
| L.O.2.6 Front seat, mid seat position and back seat service valve                          | 14   |
| L.O.2.7 Silver braze saddle valve on a suction line                                        | 14   |
| L.O.2.8 Install an access core type service valve                                          | 15   |
| L.O.2.9 Compute temperature - pressure problem                                             | 16   |
| L.O.2.10 Transfer refrigerant from storage cylinder to service cylinder                    | 17   |
| L.O.2.11 Evacuate a refrigeration system                                                   | 17   |
| L.O.2.12 Purge and triple evacuate a refrigeration system                                  | 18   |
| L.O.2.13 Pressurize a system with dry nitrogen and refrigerant and locate and repair leaks | 19   |
| L.O.2.14 Charge a refrigeration system                                                     | 20   |
| L.O.2.15 Evacuate and liquid charge a system on the high side                              | 21   |
| L.O.2.16 Check compressor operation                                                        | 22   |
| L.O.2.17 Check crankcase heater                                                            | 22   |
| L.O.2.18 Replace compressor with and without service valves                                | 23   |
| L.O.2.19 Check refrigerant                                                                 | 24   |
| <br>Unit 3: Domestic Refrigeration                                                         |      |
| L.O.3.1 Service a fan motor                                                                | 24   |
| L.O.3.2 Remove and replace a compressor                                                    | 25   |
| L.O.3.3 Replace a capillary tube                                                           | 26   |
| L.O.3.4 Diagnose and repair electrical circuits                                            | 27   |
| L.O.3.5 Remove and replace temperature controls                                            | 28   |

|                                                                          | Page |
|--------------------------------------------------------------------------|------|
| L.O.3.6 Check, remove and replace a defrost and mullion heater           | 29   |
| L.O.3.7 Check, remove and replace a defrost timer                        | 30   |
| L.O.3.8 Remove and replace the defrost termination thermostat            | 30   |
| L.O.3.9 Check and adjust a drain heater                                  | 32   |
| L.O.3.10 Locate and repair an evaporator leak                            | 32   |
| L.O.3.11 Clean capillary tubing                                          | 33   |
| L.O.3.12 Clean up after burnout                                          | 34   |
| L.O.3.13 Replace refrigerator relay                                      | 35   |
| Unit 4: Introduction to Electricity                                      |      |
| L.O.4.1 Solder and desolder components                                   | 36   |
| L.O.4.2 Sketch series and parallel circuits and calculate circuit valves | 37   |
| L.O.4.3 Construct a series and parallel circuit                          | 38   |
| L.O.4.4 Sketch a series-parallel circuit and calculate valves            | 39   |
| L.O.4.5 Measure the resistance of a single-phase compressor              | 40   |
| L.O.4.6 Measure wattage                                                  | 41   |
| L.O.4.7 Determine the microfarad rating                                  | 41   |
| L.O.4.8 Test capacitors                                                  | 42   |
| L.O.4.9 Troubleshoot electrical circuits                                 | 43   |
| L.O.4.10 Troubleshoot a magnetic starter and coil                        | 43   |
| Unit 5: Electrical Components                                            |      |
| L.O.5.1 Check voltage and amps                                           | 44   |
| L.O.5.2 Determine heat anticipator                                       | 45   |
| L.O.5.3 Adjust heat anticipator on thermostat                            | 46   |
| L.O.5.4 Install a single-stage heat and single-stage cool thermostat     | 47   |
| L.O.5.5 Install a two-stage heat and two-stage cool thermostat           | 48   |
| L.O.5.6 Wire a hot wire current relay                                    | 49   |
| L.O.5.7 Wire a magnetic, potential and fan relay                         | 49   |
| L.O.5.8 Check relays with an ohm, volt and ammeter                       | 50   |
| L.O.5.9 Wire a time-delay relay                                          | 51   |
| L.O.5.10 Wire a contractor and/or starter                                | 52   |
| L.O.5.11 Adjust/replace high and low pressure control                    | 53   |
| 5.11.1 Adjust high and low pressure control                              | 53   |
| 5.11.2 Replace high and low pressure control                             | 54   |
| L.O.5.12 Install a lockout relay                                         | 55   |
| L.O.5.13 Check a solid-state compressor motor protector                  | 56   |
| L.O.5.14 Install a bimetal, magnetic and/or thermal overload             | 56   |
| L.O.5.15 Install a capacitor with different types of relays              | 57   |
| L.O.5.16 Wire a permanent split-capacitor run compressor motor           | 58   |
| L.O.5.17 Wire capacitors in parallel and series                          | 59   |
| L.O.5.18 Check transformers                                              | 60   |
| Unit 6: Electric Motors                                                  |      |
| L.O.6.1 Determine the wattage and power factor of a motor                | 61   |
| L.O.6.2 Wire a split-phase motor                                         | 62   |
| L.O.6.3 Adjust V-belt tension                                            | 63   |

|                                                                                                      | Page |
|------------------------------------------------------------------------------------------------------|------|
| L.O.6.3 Adjust V-belt tension                                                                        | 63   |
| L.O.6.4 Check the starting components of a CSR motor                                                 | 63   |
| L.O.6.5 Wire a shaded-pole motor                                                                     | 64   |
| L.O.6.6 Replace fan blade                                                                            | 65   |
| <br>Unit 7: Wiring Diagrams                                                                          |      |
| L.O.7.1 Sketch basic schematic wiring diagram                                                        | 66   |
| L.O.7.2 Sketch a current relay wiring diagram                                                        | 66   |
| L.O.7.3 Sketch a potential relay wiring diagram                                                      | 67   |
| L.O.7.4 Sketch a hot-wire relay wiring diagram                                                       | 68   |
| L.O.7.5 Sketch a gas furnace wiring diagram                                                          | 68   |
| L.O.7.6 Sketch an outdoor condensing unit wiring diagram                                             | 69   |
| L.O.7.7 Interpret an electric furnace wiring diagram                                                 | 70   |
| L.O.7.8 Sketch a wiring diagram of a split head and cool system                                      | 70   |
| L.O.7.9 Interpret a domestic refrigeration wiring diagram                                            | 71   |
| L.O.7.10 Sketch a ladder schematic wiring diagram of a window air conditioner                        | 72   |
| <br>Unit 8: Window Air Conditioners                                                                  |      |
| L.O.8.1 Wire and install a window air conditioner including the receptacle                           | 72   |
| L.O.8.2 Check for proper cut-on and cut-off temperature                                              | 73   |
| L.O.8.3 Check the selector switch for proper operation                                               | 74   |
| L.O.8.4 Clean an air conditioner window unit                                                         | 75   |
| L.O.8.5 Remove and replace fan motor                                                                 | 76   |
| L.O.8.6 Install a hard start kit                                                                     | 77   |
| L.O.8.7 Locate and repair a refrigerant leak on a window air conditioner                             | 77   |
| <br>Unit 9: Residential and Commercial Air Conditioning                                              |      |
| L.O.9.1 Determine the temperature drop across the evaporator for a residential and commercial system | 78   |
| L.O.9.2 Determine the temperature rise across the condenser for a residential and commercial system  | 79   |
| L.O.9.3 Test operating pressures for a residential and commercial system                             | 80   |
| <br>Unit 10: Commercial Industrial Air Conditioning                                                  |      |
| L.O.10.1 Service/install an evaporator condenser                                                     | 80   |
| L.O.10.2 Repair an evaporator                                                                        | 81   |
| L.O.10.3 Wire a residential and commercial system                                                    | 82   |
| L.O.10.4 Check and service an air-cooled condenser                                                   | 83   |
| L.O.10.5 Replace an air-cooled condenser                                                             | 84   |
| L.O.10.6 Balance an evaporator for adequate air flow                                                 | 85   |
| <br>Unit 11: Commercial Refrigeration                                                                |      |
| L.O.11.1 Adjust the superheat                                                                        | 86   |
| L.O.11.2 Service a hot gas defrost system                                                            | 86   |
| L.O.11.3 Install a pump down control system                                                          | 87   |

|           |                                                                  |    |
|-----------|------------------------------------------------------------------|----|
| L.O.11.4  | Evacuate and charge a commercial refrigeration system            | 88 |
| L.O.11.5  | Adjust the high and low pressure controls of a commercial system | 89 |
| L.O.11.6  | Replace a defrost heater                                         | 90 |
| L.O.11.7  | Replace repair refrigeration tubing                              | 91 |
| L.O.11.8  | Braze joints                                                     | 91 |
| L.O.11.9  | Repair or replace a solenoid valve                               | 92 |
| L.O.11.10 | Check duct system for air circulation                            | 93 |

#### Unit 12: Gas Heating

|           |                                                   |     |
|-----------|---------------------------------------------------|-----|
| L.O.12.1  | Determine temperature rise across a furnace       | 94  |
| L.O.12.2  | Determine gas pressure of a furnace               | 95  |
| L.O.12.3  | Remove and replace a fan-limit control            | 95  |
| L.O.12.4  | Remove and replace a gas valve                    | 96  |
| L.O.12.5  | Remove and replace a transformer                  | 97  |
| L.O.12.6  | Remove and replace room thermostats               | 98  |
| L.O.12.7  | Remove and replace a blower and motor             | 99  |
| L.O.12.8  | Install and service a high efficiency gas furnace | 99  |
| L.O.12.9  | Wire a complete gas heating system                | 100 |
| L.O.12.10 | Repair or replace a solenoid valve                | 101 |
| L.O.12.11 | Adjust burners                                    | 102 |
| L.O.12.12 | Adjust a gas regulator valve                      | 103 |
| L.O.12.13 | Light and adjust pilot                            | 103 |
| L.O.12.14 | Determine the size unit needed for a given space  | 104 |
| L.O.12.15 | Check a heat exchanger                            | 105 |
| L.O.12.16 | Check a system for leaks and repairs              | 106 |
| L.O.12.17 | Install belts                                     | 107 |

#### Unit 13: Oil Heating

|          |                                          |     |
|----------|------------------------------------------|-----|
| L.O.13.1 | Service fuel oil gun burners             | 108 |
| L.O.13.2 | Install oil lines and filter             | 108 |
| L.O.13.3 | Service primary controls                 | 109 |
| L.O.13.4 | Check combustion efficiency of a furnace | 110 |

#### Unit 14: Electric Heating

|          |                                                                 |     |
|----------|-----------------------------------------------------------------|-----|
| L.O.14.1 | Determine air flow and temperature rise across electric furnace | 111 |
| 14.1.1   | Determine air flow across electric furnace                      | 111 |
| 14.1.2   | Determine temperature rise across electric furnace              | 112 |
| L.O.14.2 | Determine voltage to heating element                            | 113 |
| L.O.14.3 | Test voltage and wattage of heating element                     | 113 |
| L.O.14.4 | Inspect sequencing and safety devices                           | 114 |
| L.O.14.5 | Inspect blowers and motors                                      | 115 |
| L.O.14.6 | Determine sizes needed for electric baseboard heat              | 116 |
| L.O.14.7 | Install baseboard heat with thermostat                          | 117 |

#### Unit 15: Heat Pump, Solar and Hydronics

|          |                                           |     |
|----------|-------------------------------------------|-----|
| L.O.15.1 | Install a heat pump                       | 118 |
| L.O.15.2 | Install/service supplementary heat strips | 119 |
| L.O.15.3 | Check heat pump controls                  | 120 |
| L.O.15.4 | Replace and adjust limit switches         | 120 |

|                                                                                      | Page |
|--------------------------------------------------------------------------------------|------|
| L.O.15.5 Check system for leaks and repair                                           | 121  |
| L.O.15.6 Remove restrictions and adjust pressure of automatic valve expansion        | 122  |
| L.O.15.7 Correct restrictions in capillary tubes                                     | 123  |
| L.O.15.8 Determine temperature rise and drop across coils                            | 124  |
| L.O.15.9 Determine operating pressures                                               | 125  |
| L.O.15.10 Charge a heat pump                                                         | 126  |
| L.O.15.11 Inspect a reversing valve                                                  | 126  |
| L.O.15.12 Remove and replace common defrost controls                                 | 127  |
| L.O.15.13 Remove and replace outdoor                                                 | 128  |
| L.O.15.14 Wire heat pump thermostats                                                 | 128  |
| L.O.15.15 Determine temperature rise across a collector                              | 129  |
| L.O.15.16 Inspect circulating pumps                                                  | 130  |
| L.O.15.17 Test low water switches                                                    | 131  |
| L.O.15.18 Replace automatic expansion valves                                         | 131  |
| L.O.15.19 Replace capillary tubes                                                    | 132  |
| Unit 16: Dehumidifiers and Humidifiers                                               | 133  |
| L.O.16.1 Test humidistats                                                            | 133  |
| L.O.16.2 Install a humidifier and dehumidifier                                       | 134  |
| Unit 17: Heat Gain, Heat Loss and Duct Design                                        |      |
| L.O.7.1 Compute heat loss of a structure                                             | 134  |
| L.O.7.2 Design and install duct system for structure as per blueprint specifications | 135  |
| L.O.7.3 Compute heat gain for structures                                             | 136  |
| L.O.7.4 Measure air flow through duct system                                         | 137  |



**PROGRAM OF STUDY: INDUSTRIAL AND TECHNICAL EDUCATION**

**AREA OF STUDY: HEATING, AIR CONDITIONING AND REFRIGERATION**

**UNIT: 1 TUBING, FITTINGS, SOLDERING AND BRAZING**

**LEARNING OUTCOME:**

**1.1 Construct a flare construction and swage joint.**

**TASK(S):**

**1.1.1 Construct flare joint.**

**1.1.2 Construct swage joint.**

**TASK:**

**1.1.1 Construct flare joint.**

**PERFORMANCE STANDARD:**

**Flare joint must not leak when pressurized.**

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

**Standard tool kit, copper tubing, flare nuts, flaring tool**

**PERFORMANCE STEPS:**

**Single Flare**

- 1. Place flare nut on tubing.**
- 2. Place tubing in correct hole of flaring block.**
- 3. Place drop of oil on point of cone.**
- 4. Place flaring cone on block directly above tubing.**
- 5. Turn flaring cone clockwise slowly until flare is formed.**

**Double Flare Screw Type Tool**

- 1. Place female flare cone adapter on end of tubing.**
- 2. Place point of flare cone in recess of adapter.**
- 3. Put drop of oil on point of cone.**
- 4. Turn flare cone clockwise until inverted flare is formed.**
- 5. Place flare cone on tubing and turn clockwise until double flare is formed.**

**Punch Type Double Flare Tool**

- 1. Clamp tubing in flare block.**
- 2. Place female tool in end of tubing.**
- 3. Drive tool into tubing until inverted flare is formed.**

4. Remove female tool and replace with male tool.
5. Drive male tool into tubing until double flare is formed.

**ENABLING OBJECTIVES:**

1. Identify different type tubing.
2. Describe different type flares.
3. Demonstrate the uses of different types and uses of flaring tools.
4. Identify tubing sizes.

**UNIT: 1      TUBING, FITTINGS, SOLDERING AND BRAZING**

**LEARNING OUTCOME:**

- 1.1 Construct a flare construction and swage joint.

**TASK:**

- 1.1.2 Construct swage joint.

**PERFORMANCE STANDARD:**

Swage joint must be depth of O.D. size of tubing and must not fall apart when inverted.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, copper tubing, swage tool

**PERFORMANCE STEPS:**

Punch Type

1. Ream burr from tubing end.
2. Insert end into correct hole on anvil block.
3. Insert proper punch into tubing.
4. Hammer punch into tubing to desired depth.
5. Remove punch and check fit.

Lever Type

1. Ream burr from tubing end.
2. Place tubing over expander.
3. Squeeze lever to expand tubing to desired diameter.
4. Remove expander and check fit.

**ENABLING OBJECTIVES:**

1. Identify various types of swaging tools.
2. Identify tubing O.D. size.
3. List advantages of swage fittings.
4. Identify different types of tubing.
5. Explain procedure for soldering swage joints.

**UNIT: 1 TUBING, FITTINGS, SOLDERING AND BRAZING**

**LEARNING OUTCOME:**

- 1.2 Bend tubing to specified angles.

**TASK:**

- 1.2.1 Bend tubing to specified angles.

**PERFORMANCE STANDARD:**

Tubing must be formed to specified angle without crimping or flattening tubing.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, bending tool, blueprint with specified angles, tubing

**PERFORMANCE STEPS:**

Bend tubing using bending spring.

1. Place spring over tubing.
2. Bend to desired angle.
3. Remove spring by twisting and pulling.

Bend tubing using lever type bending tool.

1. Place tool around tubing.
2. Bend to desired angle being careful not to crimp tubing.

**ENABLING OBJECTIVES:**

1. Explain safety precautions of using tubing benders.
2. Identify types of tubing benders.
3. Describe difference between copper and aluminum tubing and their working characteristics.
4. Describe procedure for annealing copper tubing.
5. Explain operation of tubing cutters.

**UNIT: 1 TUBING, FITTINGS, SOLDERING AND BRAZING**

**LEARNING OUTCOME:**

1.3 Construct a condensate line.

**TASK:**

1.3.1 Construct condensate line.

**PERFORMANCE STANDARD:**

Condensate line must have proper trap and slope.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, fittings, tubing

**PERFORMANCE STEPS:**

1. Determine size of condensate line.
2. Select required fittings.
3. Determine length of line.
4. Form tubing to meet application.
5. Attach appropriate fitting.
6. Attach line.
7. Check trap and slope.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe types of materials used to construct condensate lines.
3. Identify various copper fittings.
4. Identify various PVC fittings.

**UNIT: 1 TUBING, FITTINGS, SOLDERING AND BRAZING**

**LEARNING OUTCOME:**

1.4 Set up an oxyacetylene welding station.

**TASK:**

1.4.1 Set up oxyacetylene welding station.

**PERFORMANCE STANDARD:**

Equipment must not leak and must perform as designed.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, oxyacetylene system, workpiece

**PERFORMANCE STEPS:**

1. Select tanks and regulators.
2. Check threads of tank.
3. Crack valve to clean connection.
4. Attach regulator to tank.
5. Crack regular valve to clean connection then attach hoses.
6. Attach hose to torch.
7. Check all fittings for being snug.
8. Check for leaks.

**ENABLING OBJECTIVES:**

1. Explain the safety needs for using oxyacetylene equipment.
2. Describe the oxygen and acetylene cylinders.
3. List the safety rules for use of the cylinders.
4. Demonstrate methods of cleaning cylinder valves.
5. Describe oxygen and acetylene regulators.
6. List the purpose and types of oxyacetylene.
7. Identify oxygen and acetylene hose.
8. Demonstrate hose cleaning methods.
9. Describe the purpose of the torch and needle valve.
10. Describe the two general classes of torches.
11. Demonstrate the correct sequence for set up.
12. Describe the methods used for leak detection and repair.
13. Explain regulator pressures.

**UNIT: 1 TUBING, FITTINGS, SOLDERING AND BRAZING**

**LEARNING OUTCOME:**

- 1.5 Light and adjust an oxyacetylene torch.

**TASK:**

- 1.5.1 Light adjust oxyacetylene torch.

**PERFORMANCE STANDARD:**

Pressure gauges must be set to desired pressure and the flame must be the correct size, color, and have distinct appearance.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, oxyacetylene equipment



#### **PERFORMANCE STEPS:**

**CAUTION: CLEAR AREA OF FLAMMABLE MATERIAL; WEAR FIRE-RETARDANT CLOTHING AND WELDING GOGGLES.**

1. Check regulator valves.  
NOTE: Valve should be off.
2. Check output gauge of regulator.  
NOTE: Gauge should read "O"; if not, bleed torch lines.
3. Open main valves on tanks.
4. Adjust regulators for desired pressure.
5. Turn on acetylene at torch and light.
6. Turn on oxygen at torch.
7. Adjust oxygen to obtain desired type of flame for job.
8. Turn off oxygen at torch.
9. Turn off acetylene at torch.
10. Shut off main valves.
11. Bleed off pressure to torch.

#### **ENABLING OBJECTIVES:**

1. Explain the relevant safety practices and procedures.
2. Explain the purpose of the tip.
3. Specify pressures for each tip size.
4. Describe the manufacturer's direction for lighting the model torch being used.
5. Describe the spark lighter.
6. Identify the three parts of the flame.
7. Distinguish the three flames by size.
8. Give the procedure for adjusting to each flame.
9. Distinguish the flames by color.
10. Demonstrate the steps in sequence to close the station down.

**UNIT: 1 TUBING, FITTINGS, SOLDERING AND BRAZING**

#### **LEARNING OUTCOME:**

- 1.6 Soft solder brass and copper fittings to copper tubing.

#### **TASK:**

- 1.6.1 Soft solder brass and copper filling to copper tubing.

#### **PERFORMANCE STANDARD:**

Soldered joint(s) must be clean and must not leak when pressurized.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, sand cloth/steel wool, solder, solder flux, tubing, tubing fittings

**PERFORMANCE STEPS:**

1. Clean joint.
2. Apply flux to joint.
3. Light torch.
4. Adjust flame to soft blue outer cone.
5. Apply heat to joint.
6. Heat until flux starts to bubble.
7. Apply solder to joint and flow around joint by moving flame around joint.
8. Allow joint to cool.
9. Clean excess flux from joint.
10. Pressurize and leak test.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain flow temperature of soft solder.
3. Identify proper procedures for preparing joint for soft soldering.
4. Determine sizes and types of tubing and fittings.
5. Identify various brass fittings.
6. Identify copper tubing by O.D. sizes.
7. Identify various types of solder and flux.

**UNIT: 1 TUBING, FITTINGS, SOLDERING AND BRAZING**

**LEARNING OUTCOME:**

- 1.7 Silver braze steel and copper tubing.

**TASK:**

- 1.7.1 Silver braze steel and copper tubing.

**PERFORMANCE STANDARD:**

Joint must be clean and must not leak when subjected to 50 psi pressure.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing equipment, flux tubing

**PERFORMANCE STEPS:**

1. Clean joints.
2. Fit joints closely and support all parts.
3. Apply flux recommended for silver brazing alloy.
4. Heat tubing evenly to recommended temperature.
5. Apply silver brazing alloy to heated tubing.
6. Cool tubing.
7. Clean joint thoroughly.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify various types of copper tubing.
3. Identify various types of flux.
4. Identify various types of sand cloth and cleaning material.
5. Name characteristics of steel tubing.
6. Describe the various types of silver brazing alloy.

**UNIT: 1 TUBING, FITTINGS, SOLDERING AND BRAZING**

**LEARNING OUTCOME:**

- 1.8 Silver braze brass fitting to copper tubing.

**TASK:**

- 1.8.1 Silver braze brass fitting to copper tubing.

**PERFORMANCE STANDARD:**

Joint must be clean and must not leak when subject to 50 psi pressure.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brass fittings, brazing equipment, copper tubing, flux silver alloy

**PERFORMANCE STEPS:**

1. Clean joints.
2. Fit joints closely and support all parts.
3. Apply flux recommended for silver brazing alloy.
4. Heat joint area evenly to recommended temperature.
5. Apply silver brazing alloy to heated parts.
6. Cool joint.
7. Clean joint thoroughly to remove all flux.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify various brass fittings.
3. Identify types of silver brazing alloys.
4. Identify types and purpose of flux.
5. Identify copper tubing by O.D. size.
6. Define term "flow point" of silver solder.

**UNIT: 1 TUBING, FITTINGS, SOLDERING AND BRAZING**

**LEARNING OUTCOME:**

- 1.9 Thread black iron pipe.

**TASK:**

- 1.9.1 Thread black iron pipe.

**PERFORMANCE STANDARD:**

Threads must mate with same size female fitting or pass through gauge inspection.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Cutting fluid, pipe, pipe die, pipe ream, vise

**PERFORMANCE STEPS:**

1. Secure pipe in vise.
2. Ream pipe to remove burr.
3. Select die and install in handle.
4. Apply cutting fluid to pipe.
5. Start die onto pipe.
6. Turn die clockwise 1/4 turn.
7. Back off die to break chip 1/8 turn.
8. Turn clockwise 3/8 turn.
9. Repeat steps 7 and 8 until desired thread length is obtained.
  - a. Apply cutting fluid as needed.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Demonstrate proper use and care of pipe dies.
3. Identify length and depth of threads.
4. Describe characteristics and purpose of thread cutting oil.
5. Identify various types of pipe fittings.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.1 Sketch a basic refrigeration system.

**TASK:**

2.1.1 Sketch basic refrigeration system.

**PERFORMANCE STANDARD:**

Drawing must include compressor, condenser, evaporator, metering device and liquid receiver. Each component must be labeled and flow direction indicated.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Paper, pencil

**PERFORMANCE STEPS:**

1. Sketch symbols of major components.
2. Connect components with lines representing the connections.
3. Label components.
4. Indicate direction of refrigerant flow.

**ENABLING OBJECTIVES:**

1. Identify components.
2. Identify high and low side components.
3. Explain where change of states occur.
4. Explain purpose of evaporator.
5. Explain purpose of condenser.
6. Explain purpose of compressor.
7. Explain purpose of metering device.
8. Explain purpose of liquid receiver.
9. Explain temperature, pressure relationships of refrigerants.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.2 Check for moisture in system.

**TASK:**

2.2.1 Check for moisture in system.



**PERFORMANCE STANDARD:**

System must be checked for moisture in system.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, compound gauge, radiant heater, refrigeration unit

**PERFORMANCE STEPS:**

1. Allow unit to completely defrost.
2. Start unit if unit fails in short time.
3. Warm refrigerant control with radiant heater.
4. Observe unit for normal function.

NOTE: Normal function indicates moisture in refrigerant.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how moisture enters system.
3. Identify moisture removal techniques.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.3 Install a filter dryer with flare and sweat fitting.

**TASK:**

2.3.1 Install filter dryer with flare and sweat fitting.

**PERFORMANCE STANDARD:**

Filter-dryer must allow for specified refrigerant flow. Fitting must form tight seal and joint must be leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, dry nitrogen, filter dryer, fittings, leak detector, refrigerant, silver solder

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Attach gauges.
3. Purge system.
4. Locate drier installation site.
5. Cut tube equal to take-up of new drier.

6. Position drier in proper direction.
7. Solder flare drier in position.
8. Remove excess flux from joint if necessary.
9. Evacuate system.
10. Charge system.
11. Leak test.
12. Restore power to unit.
13. Start system and check operation.
14. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types of dryers.
3. Explain the reasons for various sizes of dryers.
4. Describe location of dryers.
5. Explain purpose of dryers.
6. Identify brazing materials.
7. Explain how to light the torch.
8. Describe how to make braze joint.
9. Describe how to leak test joint.
10. Define "desiccant".
11. Identify various types of desiccants.
12. Explain direction of flow and reason for arrow on dryer.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

- 2.4 Install a capillary tube in a filter dryer.

**TASK:**

- 2.4.1 Install capillary tube in filter dryer.

**PERFORMANCE STANDARD:**

Capillary tube must be free of restrictions; fitting must form tight seal and joint must be leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing equipment

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Attach gauges.
3. Purge system of refrigerant.
4. Cut line at condenser and evaporator.

5. Desolder capillary tube if necessary.
6. Select and cut required length of capillary tubing.
7. Silver solder capillary tube to condenser and evaporator.
8. Clean flux.
9. Test system for leaks.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. State purpose of capillary tube.
3. Identify direction of flow of dryer.
4. Explain how to braze joint.
5. Explain how to leak test joint.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

- 2.5 Install a liquid indicator in a liquid line.

**TASK:**

- 2.5.1 Install liquid indicator in liquid line.

**PERFORMANCE STANDARD:**

Liquid indicator must be free of restriction, fitting must form tight seal and joint must be leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, leak detector, refrigerant, sight glass, solder

**PERFORMANCE STEPS:**

1. Attach gauges.
2. Purge system.
3. Cut liquid line to locate sightglass.
4. Make connection for either flare or sweat-type sightglass.
5. Clean excess flux from joint if necessary.
6. Install sightglass.
7. Purge or evaluate noncondensables from system.
8. Recharge system.
9. Remove gauges.
10. Leak test.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. State purpose of liquid indicator.

3. Identify types of liquid indicators.
4. Describe how to leak test joint.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.6 Front seat, mid seat position and back seat service valve.

**TASK:**

2.6.1 Front seat, mid seat position and back seat service valve.

**PERFORMANCE STANDARD:**

In back seated position gauge must read "0", in mid seat position system must be pressurized, in front position line must be closed.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gauges, refrigeration system

**PERFORMANCE STEPS:**

1. Attach gauges.
2. Position valve to back seat.
3. Read gauge.
4. Move valve to mid position.
5. Read gauges.
6. Move valve to front seat.
7. Read gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types of service valves.
3. Explain the purpose of valves.
4. Identify location valves.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.7 Silver braze saddle valve on a suction line.

**TASK:**

2.7.1 Silver braze saddle valve on suction line.

**PERFORMANCE STANDARD:**

Valve must form tight seal and joints must be leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing equipment, saddle valve

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Purge system.
3. Locate position of saddle valve.  
**NOTE:** Section must be straight and round.
4. Clean both saddle and tubing mating surfaces.
5. Remove piercing valve stem and gasket.
6. Apply flux.
7. Mount saddle on tubing.
8. Heat and braze.
9. Clean excess flux from valve.
10. Install piercing valve stem and gasket.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe types of saddle valves.
3. Describe location of saddle valves.
4. Describe various types of brazing materials.
5. Explain how to make a braze joint.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

- 2.8 Install an access core type service valve.

**TASK:**

- 2.8.1 Install access core type service valve.

**PERFORMANCE STANDARD:**

Valve must function and installation site must be free of excess flux and must be leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing equipment, core type service valve, flux, sand cloth, silver solder



**PERFORMANCE STEPS:**

1. Clean area to be soldered.
2. Solder valve in position.
3. Remove excess flux from soldered joint.
4. Leak test.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe various types of access valves.
3. Identify location of access valves.
4. Describe various types of brazing material.
5. Describe how to make brazed joint.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

- 2.9 Compute temperature-pressure problem.

**TASK:**

- 2.9.1 Compute temperature-pressure problem.

**PERFORMANCE STANDARD:**

Pressure and temperature must correspond to normal operating temperatures and pressure for system.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Refrigerant number, temperature-pressure chart

**PERFORMANCE STEPS:**

1. Determine type of refrigerant.
2. Determine temperature of refrigerant.
3. Locate on temperature-pressure chart temperature in left column.
4. Read across horizontally to type of refrigerant column.
5. Read/note pressure.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain operating pressure and temperature in a normal system.
3. Demonstrate proper use of pressure-temperature chart.
4. Explain how to measure ambient temperature.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.10 Transfer refrigerant from storage cylinder to service cylinder.

**TASK:**

2.10.1 Transfer refrigerant from storage cylinder to service cylinder.

**PERFORMANCE STANDARD:**

Service cylinder must be filled to no more than 85 percent of its capacity.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Scale (accurate), service cylinder, storage cylinder

**PERFORMANCE STEPS:**

1. Weigh service cylinder.
2. Determine capacity of service cylinder.
3. Attach fill tube to tank.
4. Place service cylinder on scale.
5. Open valve on service cylinder.
6. Open valve on storage cylinder.
7. Watch weight and close storage cylinder valve when desired weight is obtained.

NOTE: 85 percent of maximum capacity.

8. Close valve on service cylinder.
9. Lift service cylinder and shake endwise.

NOTE: Cylinder should have sloshing sound-air space.

**ENABLING OBJECTIVES:**

1. Explain safety standards for cylinder.
2. Identify safety precautions in transferring and handling of refrigerant.
3. Identify cylinder capacity.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.11 Evacuate a refrigeration system.

**TASK:**

2.11.1 Evacuate refrigeration system.

**PERFORMANCE STANDARD:**

Evacuated system must be free of air and moisture.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, thermocouple vacuum gauge, vacuum pump

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Attach gauges.
3. Purge system of refrigerant.
4. Connect vacuum pump.
5. Operate vacuum pump 15-30 minutes.
6. Check vacuum with vacuum gauge.
7. Observe vacuum gauge for indications of system leakage.
8. Recharge system.
  - a. Note when air and moisture content are within prescribed limits -29.25" -29.9" Hg.
9. Restore power to unit.
10. Start system and check operation.
11. Leak test.
12. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain safety precaution of evacuating system.
3. Describe proper operation of vacuum pump.
4. Describe how to connect gauges to system.
5. Explain purpose of evacuating.
6. Explain how to read mercury manometer.
7. Identify sources of moisture in system.
8. Explain results of moisture in system.
9. Explain vacuum measurement scale.
10. Demonstrate proper use of electronic vacuum gauges.
11. Explain micron vacuum scale.

**UNIT: 2      BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.12 Purge and triple evacuate a refrigeration system.

**TASK:**

2.12.1 Purge and triple evacuate refrigeration system.

**PERFORMANCE STANDARD:**

System must be free of all refrigerant and moisture.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, nitrogen gas, vacuum gauges

**PERFORMANCE STEPS:**

1. Attach gauges.
2. Front seat service valves slightly for few seconds.
3. Back seat service valves.
4. Remove center hose from keeper.
5. Crack and close gauge manifold to purge air from hose and gauge.
6. Crack high side manifold valve and close to purge air or noncondensable for high side.
7. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Demonstrate triple evacuation procedure.
3. Explain purpose of triple evacuation.
4. Explain purpose of heat lamps added to a system.
5. Explain purpose of breaking a vacuum with nitrogen.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.13 Pressurize a system with dry nitrogen and refrigerant and locate and repair leaks.

**TASK:**

2.13.1 Pressurize system with dry nitrogen and refrigerant and locate and repair leaks.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, leak detector, nitrogen cylinder, pressure reducing/control system.

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Purge system.
3. Determine maximum pressure from nameplate.
4. Connect pressure reducing/control system to nitrogen cylinder.
5. Connect to refrigeration unit.
6. Pressurize unit.
7. Use leak detector to locate leak.
8. Purge system.
9. Repair leak.
10. Braze if necessary.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe use of nitrogen and refrigerant in a system.
3. Identify three types of leak detection devices.
4. Describe how to adjust nitrogen regulator.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION****LEARNING OUTCOME:**

- 2.14 Charge a refrigeration system.

**TASK:**

- 2.14.1 Charge refrigeration system.

**PERFORMANCE STANDARD:**

System must be charged according to manufacturer's specifications for type and amount of refrigerant.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, charging cylinder, leak detector, manufacturer's service manual, refrigerant

**PERFORMANCE STEPS:**

1. Attach gauges.
2. Determine correct type and amount of charge.
3. Pressurize and leak test.
4. Evacuate system.
5. Recharge system.
6. Start unit, check system pressure against specifications.
7. Remove gauges.



**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain operation of charging system.
3. Identify various refrigerants.
4. Describe use of charging cylinder.
5. Explain how to use gauge and manifold set.
6. Explain how to determine correct high and low side pressure.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

- 2.15 Evacuate and liquid charge a system on the high side.

**TASK:**

- 2.15.1 Evacuate and liquid charge system on high side.

**PERFORMANCE STANDARD:**

System must be charged to manufacturer's specifications for type and amount of refrigerant.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's service manual, refrigerant.

**PERFORMANCE STEPS:**

1. Connect refrigerant cylinder to gauge manifold with flexible charging line to high side.
2. Let liquid into high side until pressure equalizes in container and high side.
3. Let pressure in high side and low side equalize.
4. Start unit.
5. Add additional refrigerant through low side.  
NOTE: Gas only.
6. Run unit long enough to be sure pressures are correct.
7. Remove gauge.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain hazards of liquid refrigerant.
3. Explain operation of charging system on high side.
4. Identify various refrigerants.
5. Explain use of king valve.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.16 Check compressor operation.

**TASK:**

2.16.1 Check compressor operation.

**PERFORMANCE STANDARD:**

Compressor must pump no less than 25 inches of mercury vacuum while pumping 125 psi head pressure.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gauges

**PERFORMANCE STEPS:**

1. Shut off unit.
2. Attach gauges.
3. Start unit.
4. Allow unit to operate to stabilize readings.
5. Record readings and compare to manufacturer's specifications.
6. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how to use gauge and manifold set.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.17 Check crankcase heater.

**TASK:**

2.17.1 Check crankcase heater.

**PERFORMANCE STANDARD:**

Crankcase heater must be operating within manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, crankcase heater, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Disconnect unit from power supply.
2. Locate crankcase heater.
3. Check resistance valve of heater with ohmmeter.
4. Power up unit and check voltage drop.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe function of crankcase heaters.
3. Explain connecting and reading ohmmeter.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

- 2.18 Replace compressor with and without service valves.

**TASK:**

- 2.18.1 Replace compressor with and without service valves.

**PERFORMANCE STANDARD:**

Replacement compressor must be of type and size recommended by manufacturer, securely mounted, wired in accordance with manufacturer's specifications and/or wiring diagram. Brazed joints must be free of excess flux and leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, flux, manufacturer's specifications, replacement compressor, wiping cloth, wiring schematic

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Attach gauges.
3. Purge system.
4. Cut or unbrazed lines to compressor.
5. Unbolt and remove wiring.
6. Remove compressor.
7. Tape or plug the system lines to keep moisture and dirt out of system.
8. Check that replacement compressor meets manufacturer's specifications.
9. Reverse above procedures to install replacement compressor.
10. Pressurize and leak test.
11. Evacuate system.
12. Recharge system.

13. Remove gauges.
14. Replace electrical wiring and components.
15. Connect unit to power source.
16. Start up and check out.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe types of compressors.
3. Explain procedure for purging and evacuating systems.
4. Identify signs of compressor failure.
5. Explain techniques for brazing.

**UNIT: 2 BASIC COMPRESSION REFRIGERATION**

**LEARNING OUTCOME:**

2.19 Check refrigerant.

**TASK:**

2.19.1 Check refrigerant.

**PERFORMANCE STANDARD:**

Sight glass must be clear.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gauges, refrigerant

**PERFORMANCE STEPS:**

1. Attach gauges to both high and low side.
2. Start unit and allow time for system pressures to stabilize.
3. Check refrigerant sight glass.
4. Shut down unit.
5. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify various types of gauges.
3. Identify types of refrigerants.

**UNIT: 3 DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.1 Service a fan motor.

**TASK:**

3.1.1 Service fan motor.

**PERFORMANCE STANDARD:**

Fan motor must be clean, securely attached, lubricated, and functioning within limits specified by manufacturer.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, cleaning materials, fan motor

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Locate fan motor.
3. Disconnect wiring and label for reconnection purposes.
4. Remove fan motor.
5. Clean exterior surfaces.
6. Disassemble motor if brushes are involved.
7. Lubricate as specified by manufacturer.
8. Reinstall unit and secure.
9. Reconnect electrically.
10. Test operate.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types of motor utilized for fans.
3. Describe how fan motor operates.
4. Identify function of fan in refrigeration system.

**UNIT: 3      DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.2 Remove and replace a compressor.

**TASK:**

3.2.1 Remove and replace compressor.

**PERFORMANCE STANDARD:**

Soldered joints must be leakproof, wiring must be in accordance with schematic, and compressor must be mounted securely and charged to specifications.

#### **TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing equipment, flux, manufacturer's specifications, replacement compressor

#### **PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Attach gauges.
3. Purge system.
4. Cut or unbrazed lines to compressor.
5. Unbolt and remove wiring.
6. Remove compressor.
7. Tape or plug the system lines to keep moisture and dirt out of system.
8. Check that replacement compressor meets manufacturer's specifications.
9. Reverse above procedures to install replacement compressor.
10. Pressurize and leak test.
11. Evacuate system.
12. Recharge system.
13. Remove gauges.
14. Replace electrical wiring and components.
15. Connect unit to power source.
16. Start up and check out.

#### **ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe operation of removing and replacing compressor.
3. Identify different types of compressors.
4. Explain how to follow schematic.
5. Explain how to braze leak proof joint.

#### **UNIT: 3      DOMESTIC REFRIGERATION**

#### **LEARNING OUTCOME:**

- 3.3 Replace a capillary tube.

#### **TASK:**

- 3.3.1 Replace capillary tube.

#### **PERFORMANCE STANDARD:**

Replaced capillary tube must be mechanically secure and leakproof.



**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, capillary tube, flux, sand cloth, refrigerant.

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Discharge refrigerant.
3. Unbrazed capillary tube.
4. Remove capillary tube.
5. Position new capillary tube and secure.
6. Evacuate system.
7. Recharge system.
8. Leak test.
9. Restore power to unit.
10. Start system and check operational temperature and pressure.
11. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe proper procedure for replacing tubing.
3. Identify different sizes and lengths of capillary tubing and their proper use.
4. Explain purpose of soldering capillary tubing to suction line.

**UNIT: 3 DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.4 Diagnose and repair electrical circuits.

**TASK:**

3.4.1 Diagnose and repair electrical circuits.

**PERFORMANCE STANDARD:**

All opens, shorts and grounds must be located and repaired and all malfunctioning components replaced.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, ohmmeter, replacement parts, voltmeter

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Locate wiring schematic for unit.
3. Check system for open and shorts with ohmmeter.

4. Locate shorts and repair.
5. Locate opens and repair.
6. Check continuity of components as per schematic
  - a. Remove as necessary.
7. Reassemble unit.
8. Connect to power source.
9. Operate unit.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain operation of unit using the wiring diagram.
3. Identify and explain use of test equipment for diagnosing circuit problems.
4. Explain how to read and follow schematic.
5. Describe how to use volt ohmmeter.
6. Identify shorts and open circuits.

**UNIT: 3      DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

- 3.5 Remove and replace temperature controls.

**TASK:**

- 3.5.1 Remove and replace temperature controls.

**PERFORMANCE STANDARD:**

Temperature control must be wired in accordance with schematic diagrams and unit must cycle.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, replacement temperature control

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Locate schematic for unit.
3. Locate control unit.
4. Disconnect electrically.
5. Remove control unit.
6. Position replacement control unit and secure.
7. Reconnect electrically.
8. Test operate unit through cycle.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain operation of temperature control.
3. Explain how to select proper temperature control for various refrigerators.

**UNIT: 3      DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.6 Check, remove and replace a defrost and mullion heater.

**TASK:**

3.6.1 Check, remove and replace defrost and mullion heater.

**PERFORMANCE STANDARD:**

Heater must be mechanically secure and be wired in accordance with wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, ohmmeter, replacement heater

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove breaker strips to locate heater.
3. Isolate and check circuit with ohmmeter.
4. Locate defrost heater or mullion heater.
5. Identify and tag wires and remove unit.
6. Install replacement defrost heater or mullion heater.
7. Connect unit to power source.
8. Start unit.
9. Place unit in defrost and check amperage draw.
10. Stop unit.
11. Replace breaker strips.
12. Reinstall cabinet parts.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain purpose of defrost heaters.
3. Identify and select proper defrost heaters for various refrigerator systems.

**UNIT: 3 DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.7 Check, remove and replace a defrost timer.

**TASK:**

3.7.1 Check, remove and replace defrost timer.

**PERFORMANCE STANDARD:**

Defrost timer must be mechanically secure, wired according to wiring diagram and/or manufacturer's specifications, and open or close contacts at specified times during defrost cycles.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, defrost timer, manufacturer's specifications, ohmmeter

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Locate defrost timer.
3. Disconnect wires from defrost timer.
4. Remove timer.
5. Place timer in cooling position.  
NOTE: Any place but defrost.
6. Test for zero ohms across #3 and #4 terminals.
7. Test for zero ohms across #3 and #2 terminals.
8. Turn timer into defrost cycle.  
NOTE: Around 2 o'clock mark.
9. Test for zero ohms across #3 and #4 terminals.
10. Test for zero ohms across #3 and #2 terminals.
11. Install new unit if unit fails manufacturer's instructions.
12. Install in reverse order.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain operation of defrost timer.
3. Identify and select proper defrost timers for various refrigerators.
4. Explain how to read and follow schematic.

**UNIT: 3 DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.8 Remove and replace the defrost termination thermostat.

**TASK:**

3.8.1 Remove and replace defrost termination thermostat.

**PERFORMANCE STANDARD:**

Thermostat must close and open at manufacturer's specified temperatures.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, ohmmeter

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Locate defrost thermostat.
3. Remove evaporator cover.
4. Remove screws from thermostat.
5. Disconnect thermostat wires.
6. Place thermostat in deep freeze and leave wires outside lid.
7. Attach ohmmeter.  
NOTE: When thermostat reaches manufacturer's specified low temperature contact should close and zero ohm resistance should be indicated on ohmmeter.
8. Remove thermostat from freezer.
9. Measure resistance again.  
NOTE: When thermostat reaches manufacturer's specified high temperature contacts should open and infinite resistance indicated on ohmmeter.
10. Remove ohmmeter.
11. Remount or replace thermostat.
12. Connect thermostat wires.
13. Replace evaporator cover.
14. Connect unit to power source.
15. Start unit and turn to defrost cycle.
16. Check operation.  
NOTE: Allow time for unit to cool to manufacturer's specified temperature.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify how drain heater functions.
3. Describe purpose of drain heater.
4. Explain how to connect and read ohmmeter.

**UNIT: 3 DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.9 Check and adjust a drain heater.

**TASK:**

3.9.1 Check and adjust a drain heater.

**PERFORMANCE STANDARD:**

The replaced drain heater must be mechanically secure and all electrical connections made in accordance with wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, drain heater, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove cabinet parts to expose drain heater wire terminals.
3. Locate the junction box ends of the drain heater wires.
4. Locate the drain heater.
5. Disconnect the wires from the junction box terminals.
6. Label wires for future identification.
7. Test circuit resistance.
8. Remove the old drain heater.
9. Mount the new drain heater.
10. Test circuit resistance.
11. Connect wires to the junction box terminals.
12. Connect unit to power source.
13. Start unit.
14. Check drain heater operation.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify how a drain heater functions.
3. Describe the purpose of a drain heater.
4. Explain how to connect and read an ohmmeter.

**UNIT: 3 DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.10 Locate and repair an evaporator leak.



**TASK:**

3.10.1 Locate and repair evaporator leak.

**PERFORMANCE STANDARD:**

Evaporator must not leak under pressure of 60 psi.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing equipment, leak detector

**PERFORMANCE STEPS:**

1. Disconnect unit from power supply.
2. Purge system of refrigerant.
3. Disconnect evaporator.
4. Pressurize evaporator.
5. Locate leak.
6. Clean metal around leak.
7. Purge with nitrogen while brazing or welding.  
NOTE: Use very low pressure.
8. Clean flux from brazed area.
9. Reinstall evaporator.
10. Recharge unit.
11. Test run.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Demonstrate how to mix epoxy.
3. Explain how to prepare and apply epoxy.
4. Identify function of evaporator.
5. List types of materials evaporator can be constructed of.
6. Explain pressure limitations of evaporators.

**UNIT: 3      DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.11 Clean capillary tubing.

**TASK:**

3.11.1 Clean capillary tubing.

**PERFORMANCE STANDARD:**

All restrictions must be removed and unit must cycle.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing outfit, capillary tube cleaner, clamp on service valve, leak detector

**PERFORMANCE STEPS:**

1. Attach gauges.
2. Purge system.
3. Unbrazed capillary tube.
4. Remove restrictions using capillary tube cleaner.
5. Replace capillary tube.
6. Evacuate system.
7. Recharge system.
8. Leak test system.
9. Start system and check operation.
10. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain operation of capillary tube cleaner.
3. Describe function of capillary tube.
4. Identify techniques for attaching capillary tubes.
5. Identify tubing diameters and length calculations for capillary tubing.

**UNIT: 3      DOMESTIC REFRIGERATION**

**LEARNING OUTCOME:**

3.12 Clean up after burnout.

**TASK:**

3.12.1 Clean up after burnout.

**PERFORMANCE STANDARD:**

All replaced parts must be mechanically secure and system must be clean, free of contaminants and leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing outfit, cleaning material, dry nitrogen, leak detector, moisture indicator, new compressor, new drier, refrigerant, thermocouple vacuum

#### PERFORMANCE STEPS:

1. Dismantle system.
2. Clean condenser.
3. Clean evaporator.
4. Clean metering device.
5. Clean interconnecting tubing.
6. Seal each part after cleaning.
7. Assemble complete system.
8. Flush system.
9. Install new compressor.
10. Leak test entire system.
11. Purge system with dry nitrogen.
12. Evacuate system.
13. Break vacuum with dry nitrogen.
14. Install suction and liquid driers.
15. Leak test where driers are installed.
16. Evacuate system.
17. Prepare system for operation.
18. Charge system with proper refrigerant.
19. Test system for adequate cooling.
20. Operate system for 24 hours and replace driers.
21. Test system for adequate cooling.

#### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify causes of burnout.
3. Describe procedure for purging system.
4. Identify caustic material that may be encountered.
5. Describe procedure for repairing leaks.
6. Explain brazing procedures.
7. Identify types of refrigerants.

#### UNIT: 3 DOMESTIC REFRIGERATION

##### LEARNING OUTCOME:

3.13 Replace refrigerator relay.

##### TASK:

3.13.1 Replace refrigerator relay.

##### PERFORMANCE STANDARD:

Refrigerator relay must function with range specified by manufacturer.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, replacement relay

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Locate refrigerator relay.
3. Remove relay.  
**NOTE:** Label wire for reconnect purposes.
4. Select new replacement relay.
5. Reconnect wiring and secure relay.
6. Start unit and test relay function.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify function of relay.
3. Explain how to test relays.
4. Describe operation of relay.

**UNIT: 4 INTRODUCTION TO ELECTRICITY**

**LEARNING OUTCOME:**

- 4.1 Solder and desolder components.

**TASK:**

- 4.1.1 Solder and desolder components.

**PERFORMANCE STANDARD:**

Components being soldered in must have neat, clean and electrically sound connections. Area where components have been removed must not be damaged.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, desolder wick, non-acid flux, soldering equipment

**PERFORMANCE STEPS:**

**Desolder**

1. Attach heat sinks.
2. Heat connection.
3. Lift solder with desolder wick or vacuum pickup.
4. Remove wire/fitting.

### Soldering

1. Clean connection.
2. Apply flux to connection.
3. Attach heat sinks.
4. Heat connection with soldering gun.
5. Apply solder to connection.
- NOTE: NOT TIP OF GUN.
6. Remove solder when connection has light cooling of solder.

#### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify soldering guns and their ratings and applications.
3. Identify types of fluxes and their characteristics.
4. Explain composition and types of solder available.
5. Explain function and purpose of heatsinks.

#### UNIT: 4 INTRODUCTION TO ELECTRICITY

##### LEARNING OUTCOME:

4.2 Sketch series and parallel circuits and calculate circuit values.

##### TASK:

4.2.1 Sketch series and parallel circuits and calculate circuit values.

##### PERFORMANCE STANDARD:

Sketch must be neat, use acceptable symbols, indicate voltage drops, current values, and resistance values and all calculations must be 100% correct.

##### TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Paper, pencil, reference material

##### PERFORMANCE STEPS:

1. Sketch symbols of electrical component.
2. Connect components in series and parallel configuration.
3. Label known values for components and source voltage.
4. Using "Ohm's Law" and "Kirchoff's Law" calculate unknown values.
5. Label sketch with voltage drops, resistance and current values and power values.

#### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain characteristics of a parallel circuit.
3. Explain method of solving RT in parallel.
4. Explain different methods of drawing/wiring parallel circuits.
5. Explain Ohm's Law and Ohm's Law formulas.
6. Explain characteristics of a series circuit.
7. Explain voltage drop.
8. Explain Kirchoff's Law.
9. Identify electrical symbols.

#### UNIT: 4 INTRODUCTION TO ELECTRICITY

#### LEARNING OUTCOME:

- 4.3 Construct a series and parallel circuit.

#### TASK:

- 4.3.1 Construct series and parallel circuit.

#### PERFORMANCE STANDARD:

All connections must be electrically and mechanically secure, circuit operational, and voltage and resistance equal to calculated values of circuit.

#### TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, components, electrical connectors, solder, wire

#### PERFORMANCE STEPS:

1. Determine components specified from schematic.
2. Select and arrange components.
3. Wire components as specified on schematic.
4. Solder connection.
5. Apply voltage to circuit.
6. Test voltage drop on components with voltmeter.
7. Compare readings with specification on schematic.

#### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify components from schematic symbols.
3. Explain soldering procedures.
4. Differentiate between series and parallel configurations.



5. Describe how to connect and read voltmeter.
6. Differentiate between voltmeter, ammeter, ohmmeter and multimeters.

**UNIT: 4 INTRODUCTION TO ELECTRICITY**

**LEARNING OUTCOME:**

4.4 Sketch a series-parallel circuit and calculate circuit values.

**TASK:**

4.4.1 Sketch series-parallel circuit and calculate circuit values.

**PERFORMANCE STANDARD:**

Calculations for circuit values must be 100% correct in accordance with given voltage and resistance values. Drawings must be neat and include approved symbols.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Paper, pencil, reference material

**PERFORMANCE STEPS:**

1. Sketch symbols of electrical components.
2. Connect components in series-parallel configuration.
3. Label known values for components and source voltage.
4. Reduce branch series configurations to single value.
5. Reduce branch parallel configurations to single value.
6. Calculate unknown values for segments of circuit using Ohm's Law and Kirchoff's Law.
7. Calculate subseries and subparallel configuration of unknown values using Ohm's Law and Kirchoff's Law.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify series branch.
3. Identify parallel branch.
4. Explain characteristics of series-parallel circuit.
5. Define terms voltage drop, current, resistance and power.

**UNIT: 4 INTRODUCTION TO ELECTRICITY**

**LEARNING OUTCOME:**

4.5 Measure the resistance of a single-phase compressor.

**TASK:**

4.5.1 Measure resistance of single-phase compressor.

**PERFORMANCE STANDARD:**

Resistance value must be within predetermined values specified by manufacturer.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Functional single-phase compressor, manufacturer's specifications, ohmmeter.

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Disconnect leads to compressor motor.
3. Connect wattmeter leads into system.
4. Watch meter closely.
5. Start unit.
6. Note movement of needle.

**NOTE:**

- a. Extreme right movement of needle - surge reading.
  - b. Needle should drop - start/run reading.
  - c. Needle should drop again - running reading.
7. Calculate resistance value using reading and Watt's Law and Ohm's Law.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify winding markings of different compressors.
3. Explain why starting windings have more resistance than run windings.
3. Differentiate between single-phase and three-phase.
4. Define the term "induction" in terms of voltage and current relationship.
5. Explain Ohm's Law calculation.
6. Define power surge, running current and starting current.

UNIT: 4 INTRODUCTION TO ELECTRICITY

LEARNING OUTCOME:

4.6 Measure wattage.

TASK:

4.6.1 Measure wattage.

PERFORMANCE STANDARD:

Wattage of component must be measured.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Unit to be measured, wattmeter

PERFORMANCE STEPS:

1. Disconnect unit from power source.
2. Connect wattmeter into circuit.
3. Reconnect power to unit.
4. Start unit.
5. Watch meter closely.
6. Record extreme right swing of needle.  
NOTE: Surge wattage.
7. Note position needle drops to starting draw.
8. Note position needle finally settles on running current.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Define Ohm's Law.
3. Explain phase relationship between voltage and current phase angle in motors.
4. Differentiate between running and starting current.

UNIT: 4 INTRODUCTION TO ELECTRICITY

LEARNING OUTCOME:

4.7 Determine the microfarad rating.

TASK:

4.7.1 Determine microfarad rating.

PERFORMANCE STANDARD:

Determined ratings must be within 5% of capacitor stated rating.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Capacitor analyzer, capacitors

**PERFORMANCE STEPS:**

1. Read instruction manual for capacitor analyzer.
2. Short capacitor terminals with insulated wire to discharge.
3. Connect capacitor to analyze.
4. Power up unit.
5. Note reading.
6. Remove capacitor from unit.
7. Short terminals to discharge capacitor.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Draw symbol for capacitor.
3. Explain the proper use of capacitor analyzer.
4. Identify different types of capacitors and where each type is used.
5. State units of measurement for capacitance.
6. Explain how to compute total capacitance in series and in parallel.

**UNIT: 4 INTRODUCTION TO ELECTRICITY**

**LEARNING OUTCOME:**

4.8 Test capacitors.

**TASK:**

4.8.1 Test capacitors.

**PERFORMANCE STANDARD:**

Capacitor must be rated open, shorted, grounded or operational.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Assorted capacitors, capacitor tester, ohmmeter

**PERFORMANCE STEPS:**

1. Short terminal of capacitor to discharge before handling.
2. Attach leads of ohmmeter to capacitor terminals; "O" reading indicates short.
3. Attach capacitor to capacitor test.
4. Test capacitor according to instruction manual for tester.
5. Discharge capacitor when completed.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe procedure used in checking capacitors with ohmmeter.
3. Explain importance of safely handling capacitors.
4. Explain Formula -  $MFD = 2650 \times I - E$
5. Explain capacitor reactance causes out of phase condition.  
NOTE: Voltage lags behind current.

**UNIT: 4 INTRODUCTION TO ELECTRICITY**

**LEARNING OUTCOME:**

4.9 Troubleshoot electrical circuits.

**TASK:**

4.9.1 Troubleshoot electrical circuits.

**PERFORMANCE STANDARD:**

Circuit problem must be identified.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, voltmeter, wiring schematic

**PERFORMANCE STEPS:**

1. Obtain wiring schematic for unit.
2. Connect unit to power supply.
3. Connect ground lead of voltmeter.
4. Verify voltage at terminals/pins as specified on schematic.  
NOTE: If voltage is verified entering component but output reading is off, component is defective.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe how to read voltmeter.
3. Differentiate between voltmeter and multimeter.
4. Define the term "voltage drop."

**UNIT: 4 INTRODUCTION TO ELECTRICITY**

**LEARNING OUTCOME:**

4.10 Troubleshoot a magnetic starter and coil.

**TASK:**

4.10.1 Troubleshoot magnetic starter and coil.

**PERFORMANCE STANDARD:**

Magnet starter and coil assembly must be tested and problem identified.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, ohmmeter, voltmeter, wiring schematic

**PERFORMANCE STEPS:**

1. Obtain wiring schematic for unit.
2. Disconnect unit from power supply.
3. Check continuity of unit.
4. Apply power to unit if problem is not located with ohmmeter.
5. Use voltmeter to verify voltage at points indicated on schematic.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how to read ohmmeters and voltmeters.
3. Describe the function of a magnetic starter and how it operates.

**UNIT: 5      ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.1 Check voltage and amps.

**TASK:**

5.1.1 Check voltage and amps.

**PERFORMANCE STANDARD:**

Voltage and current values must be measured and compared to specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Amprobe (ammeter), unit to be tested, voltmeter



**PERFORMANCE STEPS:**

Voltage

1. Connect ground probe of meter to frame of unit being tested.
2. Select scale on meter in excess of expected voltage.
3. Touch test probe to connection being tested.
4. Read voltage on meter.

Amp

1. Select scale on meter in excess of expected amperage.
2. Clip pick-up over wire being tested for current.
3. Read current on meter.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Differentiate between voltmeters and ammeters.
3. Identify different types of ammeters.
4. Identify limitations of ammeter.
5. Define terms "voltage," "current" and "amperage."

**UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.2 Determine heat anticipator.

**TASK:**

5.2.1 Determine heat anticipator.

**PERFORMANCE STANDARD:**

Heat anticipator values must be calculated and thermostat must open contact point circuit one degree before room reaches thermostat setting.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, ammeter, voltmeter

**PERFORMANCE STEPS:**

1. Locate operating contact points.
2. Connect clamp on ammeter onto contact point circuit.
3. Operate thermostat.
4. Measure amperage on circuit.
5. Measure voltage applied.
6. Calculate resistance value  $R=E/I$ .

7. Select resistor of calculated value.
8. Install resistor in series with contact points.
9. Operate system and check current value.
10. Selected resistor should cause contract circuit to open approximately one degree before room reaches thermostat setting.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how to use digital clamp-on ammeter.
3. Identify the function and purpose of anticipator.
4. Identify parts of thermostat.
5. Explain why heat anticipators are connected in parallel with thermostat points.

**UNIT: 5      ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.3 Adjust heat anticipator on thermostat.

**TASK:**

5.3.1 Adjust heat anticipator on thermostat.

**PERFORMANCE STANDARD:**

Current through anticipator must equal control current.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, ammeter, heat anticipator

**PERFORMANCE STEPS:**

1. Open cover to thermostat control.
2. Locate heat anticipator.
3. Determine current value from nameplate of control.
4. Connect ammeter to anticipator.
5. Adjust anticipator to obtain current reading specified.
6. Remove meter.
7. Test unit.
8. Replace thermostat cover.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain purpose of heat anticipators.

3. Explain residual heat.
4. Explain importance of matching amperage of gas valve or heat relay.

**UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.4 Install a single-stage heat and single-stage cool thermostat.

**TASK:**

5.4.1 Install single-stage heat and single-stage cool thermostat.

**PERFORMANCE STANDARD:**

Thermostat must be securely mounted, plumb, level and wired to manufacturer's specification.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, thermostat, wire

**PERFORMANCE STEPS:**

1. Locate position of thermostat.
2. Run wires to furnace/air conditioner from thermostat location.
3. Position, plumb and level thermostat backplate to wall.
4. Mark holes and attach backplate.
5. Connect wires to thermostat as specified by manufacturer.
6. Connect wire to heat/air conditioning unit as specified by manufacturer.
7. Attach cover to backplate.
8. Test operate system.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe operation of thermostat.
3. Identify different type thermostats.
4. Determine thermostat for various installations.
5. Demonstrate methods for leveling thermostats.
6. Identify terminal markings of thermostat.
7. Explain wire color code.
8. Explain terms Mercury and Bi-metal.
9. Explain how to use level and plumb-bob.
10. Explain how to calibrate thermostat.

**1UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.5 Install a two-stage heat and two-stage cool thermostat.

**TASK:**

5.5.1 Install two-stage heat and two-stage cool thermostat.

**PERFORMANCE STANDARD:**

Thermostat must be securely mounted, plumb, level, wired to manufacturer's specifications and cycle system within two degrees of setting.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, thermostat, wire

**PERFORMANCE STEPS:**

1. Locate position of thermostat.
2. Run conductors from furnace/air conditioner to thermostat location.
3. Position, plumb, level and attach thermostat backplate to wall.
4. Connect wire to terminals of thermostat following manufacturer's color code.
5. Connect wire to terminals of furnace/air conditioning unit following manufacturer's color code.
6. Replace cover on thermostat.
7. Cycle system for response to control.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe operation of two-stage heat and two-stage cool thermostat.
3. Select applications for two-stage heat and two-stage cool thermostat.
4. Identify advantages of two-stage heat and two-stage cool thermostat.
5. Explain wire color code.
6. Describe how to calibrate thermostat.
7. Identify different types of thermostats.

**UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.6 Wire a hot wire current relay.

**TASK:**

5.6.1 Wire hot wire current relay.

**PERFORMANCE STANDARD:**

Relay must be mechanically secure and wired according to wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, current relay, manufacturer's specifications, wiring schematic

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Discharge start capacitor.
3. Remove relay from motor terminals.
4. Identify each wire.
5. Mount relay in proper position.
6. Connect live voltage to wire "L" on the relay.
7. Connect wire from "S" on relay to start terminal.
8. Connect wire from "M" on the relay to run terminal on compressor motor.
9. Connect other side to compressor motor external overload.
10. Restore power to unit.
11. Check operation.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain purpose of hot wire relay.
3. Identify location of hot wire relay.
4. Explain how to determine if start winding has dropped out.
5. Explain how to install wire terminals.
6. Explain how to read schematic.

**UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.7 Wire a magnetic, potential and fan relay.

**TASK:**

5.7.1 Wire magnetic, potential and fan relay.

**PERFORMANCE STANDARD:**

Relay must be mechanically secure and wired according to wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, relay.

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Place relay line voltage contacts in series with "hot" wire according to wiring schematic.
3. Connect one side of relay coil to secondary common of 24 volt AC transformer.
4. Connect other side of relay coil to control switch.
5. Restore power to unit.
6. Start fan.
7. Check operation.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain purpose of potential relays.
3. Point out location.
4. Explain how to determine if start winding has dropped out.
5. Explain how potential relay works.
6. Explain how to install wire terminals.
7. Explain how to read schematic.
8. Describe operation of fan relays.
9. Explain purpose of fan relays.
10. Identify types of relays.

**UNIT: 5        ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.8 Check relays with an ohm, volt and ammeter.

**TASK:**

5.8.1 Check relays with ohm, volt and ammeter.

**PERFORMANCE STANDARD:**

Measurements must be within ten percent of predetermined values.



**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, ammeter, manufacturer's specifications, ohmmeter, relay to be tested, voltmeter

**PERFORMANCE STEPS:**

Ohmmeter - Resistance and Continuity

1. Consult manufacturer's specifications for terminal continuity and resistance values.
2. Select meter scale.
3. Connect leads of ohmmeter to relay at specified terminals.
4. Compare readings to specifications.

Volt and ammeter

1. Consult manufacturer's specifications for input terminals and voltage.
2. Connect meter into system at terminals specified by manufacturer.
3. Power up relay.
4. Record reading and compare to specifications.
5. Disconnect power.
6. Remove meter system.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain what resistance readings mean.
3. Identify purpose of relay.
4. Explain that different type relays have different size wire/ohm value.
5. Explain necessity of zeroing ohmmeter.
6. Describe characteristics of different start relays.
7. Explain operation of digital clamp-on ammeter.
8. Explain why the starting current will be 5-6 times higher than running current.

**UNIT: 5      ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

**5.9 Wire a time-delay relay.**

**TASK:**

**5.9.1 Wire time-delay relay.**

**PERFORMANCE STANDARD:**

Time delay relay must be mechanically secure and wired according to wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, time delay relay, wiring schematic

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove service cover.
3. Locate relay.
4. Remove wires from relay.
5. Remove relay.
6. Mount new relay.
7. Install wires on new relay according to wiring schematic.
8. Connect unit to power source.
9. Start machine.
10. Test relay.
11. Stop machine.
12. Replace service cover.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe operation of time-delay relay.
3. Explain the purpose of time-delay relay.
4. Describe different uses of time-delay relays.
5. Describe the different types of time-delay relays.
6. Explain lock-out relay.

**UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.10 Wire a contactor and/or starter.

**TASK:**

5.10.1 Wire contactor and/or starter.

**PERFORMANCE STANDARD:**

Contactor/starter must safely start and stop unit. All wire must be mechanically and electrically secure.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, contactor or starter

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove service panel.
3. Disconnect wires.
4. Remove magnetic starter/contactor.
5. Position new magnetic starter/contactor.
6. Rewire new magnetic starter/contactor.
7. Connect unit to power source.
8. Start system.
9. Check amp draw.
10. Stop system.
11. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe operation of contactor and/or starter.
3. Explain applications of contactor and/or starter.
4. Explain diagrams.
5. Explain symbols.

**UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.11 Adjust/replace high and low pressure control.

**TASK(S):**

- 5.11.1 Adjust high and low pressure control.
- 5.11.2 Replace high and low pressure control.

**TASK:**

5.11.1 Adjust high and low pressure control.

**PERFORMANCE STANDARD:**

Control must be adjusted to shut system down if head pressure rises above or suction pressure drops below predetermined values.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gauges, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Install gauges at points specified by manufacturer.
3. Cycle unit.
4. Adjust control on high pressure side.
5. Adjust control on low pressure side.
6. Disconnect power.
7. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain purpose of high pressure controls.
3. Explain various types of controls.
4. Describe how to simulate high head pressure condition.
5. Explain how to attach and read gauges.
6. Determine correct settings of high pressure controls.
7. Identify range and differential.
8. Identify purpose of low pressure switch.
9. Simulate improper air flow across an evaporator.

**UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.11 Adjust/replace high and low pressure control.

**TASK:**

5.11.2 Replace high and low pressure control.

**PERFORMANCE STANDARD:**

Control switch must be mechanically secure, electrical connections made to wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specs, pressure switch, refrigerant

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Purge system.
3. Remove mounting screws.
4. Remove electrical wires from control.
5. Remove capillary bulb from high side of system.
6. Mount new control switch.
7. Connect electrical wires.
8. Connect capillary bulb.

9. Evacuate system.
10. Recharge system.
11. Leak test.
12. Start and cycle system.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify function of high/low pressure control switch.
3. Explain how to calibrate high/low pressure switch.
4. Describe how to purge system.
5. Describe how to evacuate system.
6. Identify function of capillary tube for switch operation.

**UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.12 Install a lockout relay.

**TASK:**

5.12.1 Install lockout relay.

**PERFORMANCE STANDARD:**

Lockout relay must be securely attached and wired according to wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, lockout relay, manufacturer's specifications, wiring schematic

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Disconnect wires.
3. Remove old lockout relay.
4. Mount new lockout relay.
5. Connect wires according to wiring schematic.
6. Restore power to unit.
7. Trip pressure control to test lockout relay.
8. Reset thermostat to put unit back into operation.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe purpose and function of lockout relay.
3. Identify characteristics of malfunctioning lockout relay.

4. Explain how to test relays.
5. Explain how to connect and read voltmeters, ohmmeters and multimeters.

**UNIT: 5      ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.13 Check a solid-state compressor motor protector.

**TASK:**

5.13.1 Check solid-state compressor motor protector.

**PERFORMANCE STANDARD:**

Solid-state protector must be tested and operated within tolerances specified by manufacturer.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, ohmmeter, voltmeter

**PERFORMANCE STEPS:**

1. Disconnect unit from power supply.
2. Locate solid-state protector in unit.
3. Identify model and obtain manufacturer's specifications and test procedure.
4. Check continuity of protector following manufacturer's procedure.  
NOTE: Care must be given to polarity.
5. Power up system.
6. Check voltage at terminals specified by manufacturer.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. List advantages of solid-state control units.
3. Describe function of solid-state compressor motor protector.

**UNIT: 5      ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.14 Install a bimetal, magnetic and/or thermal overload.



**TASK:**

5.14.1 Install bimetal, magnetic and/or thermal overload.

**PERFORMANCE STANDARD:**

Overload control must be securely attached, wiring must be mechanically and electrically secured, and overload must safely open the control circuit under temperature and current overload.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, overload protector

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Locate overload protector.
3. Disconnect wiring from protector.
4. Remove protector from housing.
5. Install replacement protector and secure.
6. Connect protector electrically.  
NOTE: Consult manufacturer's wiring schematic for color code and connection sequence.
7. Adjust to manufacturer's specifications.
8. Connect power.
9. Cycle system.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe operation of magnetic overload.
3. Explain applications of magnetic overloads.
4. Describe other types of overloads.
5. Point out possible locations in circuits.
6. Describe the operation of thermal overload.
7. Explain uses of thermal overload.
8. Describe operation of bimetal protector.

**UNIT: 5      ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.15 Install a capacitor with different types of relays.

**TASK:**

5.15.1 Install capacitor with different types of relays.

**PERFORMANCE STANDARD:**

All electrical connections must be secure and in accordance with wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, capacitor, manufacturer's specifications, relay, wiring schematics

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove panel cover.
3. Remove wires from start capacitor.
4. Test capacitor.
5. Remove old capacitor, if defective.
6. Install new capacitor.
7. Connect wires according to wiring schematic.
8. Restore power to unit.
9. Start unit.
10. Test amperes.
11. Replace panel cover.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain proper use and characteristics of start capacitor.
3. Describe the proper operation of different relays.
4. Draw symbols related to capacitors and relays.

**UNIT: 5        ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.16 Wire a permanent split-capacitor run compressor motor.

**TASK:**

5.16.1 Wire permanent split-capacitor run compressor motor.

**PERFORMANCE STANDARD:**

Capacitor must be mechanically secure with all electrical connections securely attached in accordance with the wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, permanent split-capacitor unit, wiring schematic

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove panel cover.
3. Disconnect wires from run capacitor.
4. Test capacitor.
5. Remove old capacitor, if faulty.
6. Install new capacitor.
7. Connect wires to new capacitor according to wiring schematic.
8. Restore power to unit.
9. Start unit.
10. Test amperage draw.
11. Replace panel cover.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe the operating characteristics of a PSC motor.
3. Explain the advantages and disadvantages of a PSC motor.
4. Identify motor leads and determine if open, shorted or grounded.
5. Explain the location and type capacitor used.
6. Describe procedure for testing capacitor.
7. Describe the method for changing direction of rotation.
8. Give some example uses of PSC motors.

**UNIT: 5      ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.17 Wire capacitors in parallel and series.

**TASK:**

5.17.1 Wire capacitors in parallel and series.

**PERFORMANCE STANDARD:**

Capacitors must be connected together and must be securely electrically. Capacitors must not be electrically damaged.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, capacitors, soldering, wiring schematic

**PERFORMANCE STEPS:**

1. Selected specified capacitors.
2. Discharge capacitors.
3. Arrange capacitors according to schematic.
4. Clean terminals.

5. Connect wire (leads).
6. Heat sink capacitor.
7. Apply heat to connection.
8. Apply solder.
9. Clean off excess flux.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe the application of a capacitor in parallel and series.
3. Identify symbol for capacitor.
4. Explain wiring diagrams.
5. Describe different type capacitors and how used.
6. Explain different units of measurement for capacitance.

**UNIT: 5 ELECTRICAL COMPONENTS**

**LEARNING OUTCOME:**

5.18 Check transformers.

**TASK:**

5.18.1 Check transformers.

**PERFORMANCE STANDARD:**

Primary and secondary windings must show measurable resistance and output voltage must be within range specified by manufacturer when powered with specified input.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, ohmmeter, transformer, voltmeter

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Locate transformer.
3. Remove wires from transformer.
4. Measure resistance of primary winding.
5. Measure resistance of secondary winding.
6. Connect wires to transformer.
7. Restore power to unit.
8. Check input voltage.
9. Check output voltage.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Differentiate between step-up and step-down transformer.
3. Describe transformer action.
4. Explain how to connect, operate and read a ohmmeter and voltmeter.
5. Explain turn ratio.

**UNIT: 6        ELECTRIC MOTORS**

**LEARNING OUTCOME:**

- 6.1 Determine the wattage and power factor of a motor.

**TASK:**

- 6.1.1 Determine wattage and power factor of a motor.

**PERFORMANCE STANDARD:**

Wattage and power factor must be calculated to within 5 percent of manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Ammeter, manufacturer's specifications, motor, voltmeter, wattmeter

**PERFORMANCE STEPS:**

1. Connect ammeter and voltmeter to motor.
2. Connect motor to power source.
3. Start motor and record voltage and amperage.
4. Stop motor/disconnect power.
5. Remove voltmeter and ammeter.
6. Connect wattmeter.
7. Power up motor and record wattage.

NOTE: Use Formula  $PF = \frac{\text{wattmeter reading}}{\text{voltmeter reading} \times \text{ammeter reading}}$  (PF = wattmeter/volt x amps).

**ENABLING OBJECTIVES:**

1. Explain the relevant safety practices and procedures.
2. Explain how to estimate the wattage using the information on the nameplate.
3. Describe phase relationship between voltage and current in electric motors.
4. Explain how to connect and operate voltmeter and ammeter.

**UNIT: 6      ELECTRIC MOTORS**

**LEARNING OUTCOME:**

6.2 Wire a split-phase motor.

**TASK:**

6.2.1 Wire split-phase motor.

**PERFORMANCE STANDARD:**

Motor must be correctly connected to power source; connections must be mechanically and electrically secure with no exposed wiring and motor must run at rated speed.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's manual, split-phase motor, tachometer

**PERFORMANCE STEPS:**

1. Secure motor to mounting bracket.
2. Open access plate to terminals.
3. Install wire to junction box of motor.
4. Connect wires to terminals following manufacturer's specifications.
5. Close access plate.
6. Test run motor.
7. Check for shorts.
8. Check RPM with tachometer.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe operating characteristics of split-phase induction motor.
3. Explain advantages and disadvantages of split-phase induction motor.
4. Explain terminal numbering and color identification system for motor leads.
5. Identify motor leads and determine if open, shorted, or grounded.
6. Explain operation of centrifugal switch.
7. Explain correct procedure for measuring starting and running current.
8. Describe method of changing direction of rotation.



**UNIT: 6      ELECTRIC MOTORS**

**LEARNING OUTCOME:**

6.3 Adjust V-belt tension.

**TASK:**

6.3.1 Adjust V-belt tension.

**PERFORMANCE STANDARD:**

Belt must be adjusted to within (+ or -) 1/8 inch of manufacturer's recommended tension.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specification

**PERFORMANCE STEPS:**

1. Disconnect motor from power source.
2. Loosen pulley set screw.
3. Check deflection at center of greatest free span of belt.
4. Adjust deflection to manufacturer's specifications by prying on loosened pulley.
5. Hold pulley firmly in place while tightening set screw.
6. Connect motor to power source.
7. Test run unit.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify different types of belts.
3. Describe different methods of belt adjustment.
4. Explain belt sizing and numbering.

**UNIT: 6      ELECTRIC MOTORS**

**LEARNING OUTCOME:**

6.4 Check the starting components of a CSR motor.

**TASK:**

6.4.1 Check starting components of CSR motor.

**PERFORMANCE STANDARD:**

Components must be identified as either open, shorted, grounded or good.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, capacitor tester, ohmmeter, tachometer

**PERFORMANCE STEPS:**

1. Disconnect unit from power supply.
2. Disconnect motor electrically.
3. Remove motor from unit.
4. Open access plate.
5. Test capacitor.
6. Test centrifugal switch for continuity.
7. Check continuity of main and auxiliary wiring.
8. Check winds for shorts and ground.
9. Identify components that are defective.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe operating characteristics of CSR motor.
3. Explain advantages and disadvantages of CSR motor.
4. Explain location, type and purpose of both capacitors.
5. Identify ways to compute total capacitance when capacitors are wired in parallel and series.
6. Describe procedures for testing capacitors.
7. Identify motor leads and determine if open, shorted or grounded.
8. Explain purpose of centrifugal switch in CSR motor.
9. Identify uses of CSR motors.
10. Describe method for changing direction of rotation.

**UNIT: 6      ELECTRIC MOTORS**

**LEARNING OUTCOME:**

6.5 Wire a shaded-pole motor.

**TASK:**

6.5.1 Wire shaded-pole motor.

**PERFORMANCE STANDARD:**

Motor must operate at number of speeds for which it was designed when selector switch is moved. Motor must carry its load without being overloaded.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, control switch, manufacturer's manual, shaded-pole motor, tachometer, wiring schematics

#### PERFORMANCE STEPS:

1. Read manufacturer's instructions.
2. Check motor for horsepower and speed rating.
3. Attach specified devices to shaft.
4. Mount motor in mounting bracket and secure.
5. Connect leads following wiring schematic.
6. Check connections for accuracy and secure.
7. Power up unit.
8. Test operate.
9. Verify speeds.

#### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Describe operating characteristics of shaded-pole motor.
3. Explain advantages and disadvantages of shaded-pole motor.
4. Explain different ways of reversing shaded-pole motors, depending on type.
5. Explain formula for computing RPM for single-phase motors.

#### UNIT: 6 ELECTRIC MOTORS

#### LEARNING OUTCOME:

- 6.6 Replace fan blade.

#### TASK:

- 6.6.1 Replace fan blade.

#### PERFORMANCE STANDARD:

Fan blade must be mechanically secure; turn in direction of arrow indicator, and must have clearance from surrounding case or shroud.

#### TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, fan blade, fan blade puller

#### PERFORMANCE STEPS:

1. Disconnect unit from power source.
2. Loosen set screw on fan blade.
3. Remove fan blade.  
NOTE: Use puller if necessary.
4. Position new fan blade.
5. Tighten set screw.
6. Rotate blade to check clearance.

7. Connect unit to power source.
8. Start unit.
9. Check rotation direction, balance and clearance.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe function of double allen screw locking.
3. Define term "balance" and describe how blade is balanced.
4. Differentiate between "slip fit" and "shrink fit."
5. Explain how to use puller.

**UNIT: 7 WIRING DIAGRAMS**

**LEARNING OUTCOME:**

- 7.1 Sketch basic schematic wiring diagram.

**TASK:**

- 7.1.1 Sketch basic schematic wiring diagram.

**PERFORMANCE STANDARD:**

Schematic diagram must match pictorial diagram.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Paper/pencil, pictorial diagram

**PERFORMANCE STEPS:**

1. Examine pictorial diagram.
2. Sketch unit's major components using appropriate symbols.
3. Label components.
4. Identify terminals, connections and cables.

**ENABLING OBJECTIVES:**

1. Identify wiring symbols and methods.
2. Explain procedures used in understanding schematic drawing.

**UNIT: 7 WIRING DIAGRAMS**

**LEARNING OUTCOME:**

- 7.2 Sketch a current relay wiring diagram.

**TASK:**

7.2.1 Sketch current relay wiring diagram.

**PERFORMANCE STANDARD:**

Diagram must match current relay wiring.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Paper/pencil, current relay

**PERFORMANCE STEPS:**

1. Examine current relay.
2. Sketch current relay using electrical symbols.
3. Label major components.
4. Identify terminals and connections.

**ENABLING OBJECTIVES:**

1. Identify wiring diagrams and symbols.
2. Explain wiring diagram and symbols.
3. Explain operating characteristics of current relay.

**UNIT: 7      WIRING DIAGRAMS**

**LEARNING OUTCOME:**

7.3 Sketch a potential relay wiring diagram.

**TASK:**

7.3.1 Sketch potential relay wiring diagram.

**PERFORMANCE STANDARD:**

Diagram must match potential relay wiring.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Paper/pencil, potential relay

**PERFORMANCE STEPS:**

1. Examine potential relay.
2. Sketch potential relay using electrical symbols.
3. Label major components.
4. Identify terminals and connections.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain operating characteristics of potential relay.
3. Explain internal layout of potential relay.

**UNIT: 7      WIRING DIAGRAMS**

**LEARNING OUTCOME:**

7.4 Sketch a hot-wire relay wiring diagram.

**TASK:**

7.4.1 Sketch hot-wire relay wiring diagram.

**PERFORMANCE STANDARD:**

Diagram must match hot-wire relay wiring.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Hot-wire relay, paper/pencil

**PERFORMANCE STEPS:**

1. Examine hot-wire relay.
2. Sketch hot-wire relay using electrical symbols.
3. Label major components.
4. Label terminals and connections.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how hot-wire relay works.
3. Identify location of hot-wire relay.

**UNIT: 7      WIRING DIAGRAMS**

**LEARNING OUTCOME:**

7.5 Sketch a gas furnace wiring diagram.

**TASK:**

7.5.1 Sketch gas furnace wiring diagram.

**PERFORMANCE STANDARD:**

Diagram must match that of furnace.



**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Gas furnace properly wired, paper/pencil

**PERFORMANCE STEPS:**

1. Examine gas furnace unit.
2. Sketch unit's major components using appropriate symbols.
3. Label components.
4. Connect components.
5. Label terminals, connections and cables.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain safety precautions for gas fired furnace.
3. Describe operation of gas fired furnace.
4. Identify schematic symbols.
5. Explain operating sequence of gas furnace.

**UNIT: 7      WIRING DIAGRAMS**

**LEARNING OUTCOME:**

- 7.6 Sketch an outdoor condensing unit wiring diagram.

**TASK:**

- 7.6.1 Sketch outdoor condensing unit wiring diagram.

**PERFORMANCE STANDARD:**

Diagram must match condensing unit wiring.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Paper/pencil, outdoor condensing unit

**PERFORMANCE STEPS:**

1. Examine outdoor condensing unit.
2. Sketch unit's major components using appropriate symbols.
3. Label components.
4. Connect components.
5. Label terminals, connections and cables.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify wiring symbols.
3. Explain operating sequence of outdoor condensing unit.

UNIT: 7      WIRING DIAGRAMS

LEARNING OUTCOME:

7.7 Interpret an electric furnace wiring diagram.

TASK:

7.7.1 Interpret electric furnace wiring diagram.

PERFORMANCE STANDARD:

Furnace must have all components shown on diagram and be wired according to diagram.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Electric furnace system, electric furnace wiring schematic

PERFORMANCE STEPS:

1. Examine wiring diagram.
2. Examine electric furnace.
3. Identify from diagram all component parts on furnace.
4. Verify that electrical connections on furnace match wiring schematic.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Describe operation of electric furnace.
3. Identify wiring diagram symbols.
4. Explain operating sequence of electric furnace.

UNIT: 7      WIRING DIAGRAMS

LEARNING OUTCOME:

7.8 Sketch a wiring diagram of a split heat and cool system.

TASK:

7.8.1 Sketch wiring diagram of split heat and cool system.

PERFORMANCE STANDARD:

Diagram must match split heat and cool system wiring.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Paper/pencil, split heat and cool system

**PERFORMANCE STEPS:**

1. Examine split heat and cool system.
2. Sketch unit's major components using appropriate symbols.
3. Label components.
4. Connect component parts.
5. Label terminals, connections and cables.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Know proper application of split system.
3. Identify wiring diagram symbols.
4. Explain operating sequence of split systems.

**UNIT: 7      WIRING DIAGRAMS**

**LEARNING OUTCOME:**

7.9 Interpret a domestic refrigeration wiring diagram.

**TASK:**

7.9.1 Interpret domestic refrigeration wiring diagram.

**PERFORMANCE STANDARD:**

Domestic refrigeration unit must have all components shown on diagram and be wired according to diagram.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Domestic refrigerator, domestic refrigerator wiring diagram

**PERFORMANCE STEPS:**

1. Examine wiring diagram.
2. Examine refrigerator.
3. Identify from schematic all component parts on refrigerator.
4. Verify that electrical connections on refrigerator match wiring schematic.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain operating sequence of domestic refrigerator.
3. Identify schematic symbols.
4. Explain how to draw schematic.

**UNIT: 7      WIRING DIAGRAMS**

**LEARNING OUTCOME:**

7.10 Sketch a ladder schematic wiring diagram of a window air conditioner.

**TASK:**

7.10.1 Sketch ladder schematic wiring diagram of window air conditioner.

**PERFORMANCE STANDARD:**

Diagram must match wiring of unit.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Paper/pencil, window air conditioner

**PERFORMANCE STEPS:**

1. Examine window air conditioner.
2. Sketch unit's major components using appropriate symbols.
3. Label components.
4. Connect component parts.
5. Label terminals, connections and cables.

**ENABLING OBJECTIVES:**

1. Know operation and characteristics of window unit.
2. Identify schematic symbols.
3. Explain how to draw a schematic.
4. Explain operating sequence of a window air conditioner.

**UNIT: 8      WINDOW AIR CONDITIONERS**

**LEARNING OUTCOME:**

8.1 Wire and install a window air conditioner including the receptacle.

**TASK:**

8.1.1 Wire and install window air conditioner including receptacle.

#### PERFORMANCE STANDARD:

Air conditioner must be securely mounted in window as per manufacturer's specifications and wiring must meet National Electrical Code requirements.

#### TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, electrical supplies, manufacturer's installation manual

#### PERFORMANCE STEPS:

1. Determine location of air conditioner.
2. Locate position of outlet.
3. Determine wiring requirements, volts and amperage, from manufacturer's manual.
4. Select wire, outlet type and size and style of overload protector.
5. Run cable from fuse box to outlet.
6. Install outlet in wall.
7. Connect cable in fuse box.
8. Test electrical circuit.
9. Install mounting bracket in window.
10. Slide air conditioning unit onto brackets.
11. Secure air conditioner to window frame.  
NOTE: See manufacturer's specifications.
12. Plug unit into power supply.
13. Test run unit.

#### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain how to wire and install receptacle.
3. Determine correct wire size for installation.
4. Determine correct size of current protection device for wiring and installation.
5. Explain wiring diagram.
6. Determine operating sequence of window air conditioner.
7. Identify wire terminals.
8. Explain purpose and procedure for using ohmmeter.
9. Identify electrical components.

UNIT: 8 WINDOW AIR CONDITIONERS

#### LEARNING OUTCOME:

- 8.2 Check for proper cut-on and cut-off temperature.

**TASK:**

8.2.1 Check for proper cut-on and cut-off temperature.

**PERFORMANCE STANDARD:**

Thermostat must cycle unit with correct differential.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, thermometer

**PERFORMANCE STEPS:**

1. Record temperature of room.
2. Set thermostat two degrees colder than room temperature.
3. Start air conditioning unit.
4. Room temperature should drop to desired setting and air conditioner should stop cooling cycle.

NOTE: When room warms to within one degree of desired setting, cool cycle should start.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Define cut-in and cut-out.
3. Determine thermostat location.
4. Demonstrate uses of ohmmeter.

**UNIT: 8 WINDOW AIR CONDITIONERS**

**LEARNING OUTCOME:**

8.3 Check the selector switch for proper operation.

**TASK:**

8.3.1 Check selector switch for proper operation.

**PERFORMANCE STANDARD:**

Selector switch must be examined to determine if switch is operating according to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, operating manual for air conditioner, thermometer, window air conditioner



**PERFORMANCE STEPS:**

1. Read operating manual for air conditioner.
2. Position thermometer in front of discharge grill.
3. Test operate air conditioner on all settings, allowing 5 minutes on each setting.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Measure resistance with an ohmmeter.
3. Determine location of selector switch.
4. Determine sequence of operation of window unit.

**UNIT: 8 WINDOW AIR CONDITIONERS**

**LEARNING OUTCOME:**

8.4 Clean an air conditioner window unit.

**TASK:**

8.4.1 Clean air conditioner window unit.

**PERFORMANCE STANDARD:**

Air must pass through evaporator and condenser unimpeded.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brush, cleaning material, vacuum cleaner

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove front access panels.
3. Remove and clean filter.
4. Clean louvers and front grill.
5. Remove dirt from around evaporator and condenser unit.
6. Reinstall grills/louvers.
7. Replace access panels.
8. Reconnect to power source.
9. Test operate unit.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain procedures to remove and replace condenser.
3. Explain procedure for straightening condenser fins.
4. Describe methods of cleaning unit.

5. Identify different types of cleaning materials.
6. Describe methods of water proofing and checking electrical components.

**UNIT: 8 WINDOW AIR CONDITIONERS**

**LEARNING OUTCOME:**

8.5 Remove and replace fan motor.

**TASK:**

8.5.1 Remove and replace fan motor.

**PERFORMANCE STANDARD:**

Fan must turn in specified direction, blades must not strike any metal, and electrical connections must be mechanically and electrically secure.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, fan motor

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove unit from window.
3. Remove cabinet cover.
4. Locate fan motor.
5. Disconnect electrical wiring.
6. Remove motor from mount.
7. Remove fan blade from motor.
8. Mount fan blade on new motor.
9. Secure motor to mount.
10. Connect electrically.
11. Replace cabinet cover.
12. Reinstall unit in window.
13. Test run unit.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe procedures for removing fan motor.
3. Describe methods of removing fanblade from rusty shaft.
4. Describe correct methods of wiring motor.
5. Identify different fan motors and their proper use.

**UNIT: 8 WINDOW AIR CONDITIONERS**

**LEARNING OUTCOME:**

8.6 Install a hard start kit.

**TASK:**

8.6.1 Install hard start kit.

**PERFORMANCE STANDARD:**

Potential relay and start capacitor must be securely attached and wired according to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, electrical connectors, hard start kit, manufacturer's specifications, wiring schematic

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Mount relay and capacitor.
3. Connect wires according to wiring schematic.
4. Restore power to unit.
5. Test amperage draw with ammeter.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain purpose of hard start kit.
3. Identify various components of hard start kit.
4. Describe procedure for wiring CSR motor.

**UNIT: 8 WINDOW AIR CONDITIONERS**

**LEARNING OUTCOME:**

8.7 Locate and repair a refrigerant leak on a window air conditioner.

**TASK:**

8.7.1 Locate and repair refrigerant leak on window air conditioner.

**PERFORMANCE STANDARD:**

All leaks must be detected and repaired.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, electronic leak detector, repair equipment and supplies, soap solution

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove from window opening.
3. Attach gauges.
4. Pressurize system with refrigerant.
5. Leak test by sniffing tubing and components with electronic detector or halide torch or daubing tubing and components with soap solution.
6. Repair detected leaks.
7. Retest for leaks.
8. Remove gauges.
9. Reinstall in window opening.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe steps in locating refrigerant leak.
3. Determine procedure for repairing leak.
4. Describe use of electronic leak detector.
5. Describe use of halide leak detector.

**UNIT: 9      RESIDENTIAL AND COMMERCIAL AIR CONDITIONING**

**LEARNING OUTCOME:**

9.1 Determine the temperature drop across the evaporator for a residential and commercial system.

**TASK:**

9.1.1 Determine temperature drop across evaporator for residential and commercial system.

**PERFORMANCE STANDARD:**

Temperature measurement must be within two degrees of manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, air conditioner, manufacturer's specifications, thermometer

**PERFORMANCE STEPS:**

1. Remove grill cover.
2. Operate system.
3. Position thermometer at intake of evaporator and record.
4. Position thermometer at output of evaporator and record.
5. Compare measured readings with manufacturer's specifications.
6. Replace grill cover.

**ENABLING OBJECTIVES:**

1. Explain procedure for reading thermometer.
2. Explain where to take readings.

**UNIT: 9          RESIDENTIAL AND COMMERCIAL AIR CONDITIONING**

**LEARNING OUTCOME:**

9.2 Determine the temperature rise across the condenser for a residential and commercial system.

**TASK:**

9.2.1 Determine temperature rise across condenser for residential and commercial system.

**PERFORMANCE STANDARD:**

Temperature measurement must be within two degrees of manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, air conditioner, manufacturer's specifications, thermometer

**PERFORMANCE STEPS:**

1. Remove grill cover.
2. Operate system.
3. Position thermometer at intake side of condenser, record reading.
4. Position thermometer in condenser and record reading.
5. Compare measured reading with manufacturer's specification.
6. Replace grill cover.

**ENABLING OBJECTIVES:**

1. Explain procedure for reading thermometer.
2. Determine where to take readings.

**UNIT: 9 RESIDENTIAL AND COMMERCIAL AIR CONDITIONING****LEARNING OUTCOME:**

9.3 Test operating pressures for a residential and commercial system.

**TASK:**

9.3.1 Test operating pressures for residential and commercial system.

**PERFORMANCE STANDARD:**

Pressure readings must be within two psi of manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, pressure gauges

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove unit from window.
3. Remove cabinet cover.
4. Attach pressure gauges.
5. Power up unit.
6. Cycle unit.
7. Record pressure reading.
8. Compare reading with manufacturer's specifications.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain procedure for connecting gauge and manifold set.
3. Explain how to read pressure gauges.
4. Identify high and low side service valves.
5. Explain procedure for operating service valves.
6. Explain use of pressure temperature charts.

**UNIT: 10 COMMERCIAL/INDUSTRIAL AIR CONDITIONING****LEARNING OUTCOME:**

10.1 Service/install an evaporator condenser.

**TASK:**

10.1.1 Service/install evaporator condenser.



#### PERFORMANCE STANDARD:

Condenser must be level and mechanically secure, piping and electrical connections must be according to manufacturer's specifications and refrigerant lines must be mechanically secure, leakproof and hold charge.

#### TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, leak detector, manufacturer's installation manual, vacuum pump

#### PERFORMANCE STEPS:

1. Level condenser on concrete pad.
2. Connect piping according to manufacturer's installation manual.
3. Connect electrical supply.
4. Fill water pump.
5. Attach gauges.
6. Leak test refrigerant lines.
7. Evacuate refrigerant system.
8. Charge system.
9. Leak test.
10. Start system and check operating temperature and pressure.
11. Remove gauges.

#### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Describe various cleaning chemicals.
3. Determine static pressure drop.
4. Explain cleaning procedures.
5. Describe location of evaporator and condenser.

#### UNIT: 10 COMMERCIAL/INDUSTRIAL AIR CONDITIONING

#### LEARNING OUTCOME:

10.2 Repair an evaporator.

#### TASK:

10.2.1 Repair evaporator.

#### PERFORMANCE STANDARD:

Replaced evaporator lines and electrical connections must be mechanically secure and in accordance with wiring diagram and/or manufacturer's specifications. Evaporator must be free of internal moisture and leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gauges, leak detector, refrigerant

**PERFORMANCE STEPS:**

1. Locate leaks and mark.
2. Disconnect unit from power source.
3. Attach gauges.
4. Discharge refrigerant.
5. Cut and seal refrigerant lines.
6. Remove evaporator.
7. Clean area where leak is located.
8. Silver solder/braze leak.
9. Clean excess flux from repair.
10. Reinstall evaporator.
11. Evacuate system.
12. Charge system with proper refrigerant according to sight glass.
13. Allow 20 minutes for system to balance pressures.
14. Leak test.
15. Restore power to unit.
16. Start unit and check super heat and adjust if required.
17. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how to purge, evacuate and charge refrigerant system.
3. Identify materials used for repairing evaporators.
4. Identify function of evaporator.
5. Identify brazing equipment.

**UNIT: 10      COMMERCIAL/INDUSTRIAL AIR CONDITIONING**

**LEARNING OUTCOME:**

10.3 Wire a residential and commercial system.

**TASK:**

10.3.1 Wire residential and commercial system.

**PERFORMANCE STANDARD:**

Unit must be wired and operate as designated by manufacturer.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, air conditioning unit, manufacturer's installation manual

**PERFORMANCE STEPS:**

1. Read manufacturer's installation manual.
2. Install thermostat control unit.
3. Connect wiring following manufacturer's color code and schematic.
4. Recheck connection to ensure that it is secure.
5. Check color code.
6. Start crankcase heater and allow unit to heat required time.
7. Test operate system.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how to wire air conditioning unit to line voltage.
3. Explain how to wire air conditioning unit to control voltage.
4. Determine types and sizes of current protection devices.
5. Determine high voltage wire sizes.
6. Explain wiring schematic.
7. Identify wire terminals.

**UNIT: 10      COMMERCIAL/INDUSTRIAL AIR CONDITIONING**

**LEARNING OUTCOME:**

10.4 Check and service an air-cooled condenser.

**TASK:**

10.4.1 Check and service air-cooled condenser.

**PERFORMANCE STANDARD:**

Condenser must be cleaned, circulating air freely and leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brush, leak detector, velocity meter, vacuum cleaner

**PERFORMANCE STEPS:**

1. Remove service panel.
2. Clean fins.
3. Remove obstructions.

4. Test for leaks.
5. Cycle system and check air flow.
6. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify function of air-cooled condenser.
3. Identify meters for checking air flow.
4. Explain procedures for repairing condensers.
5. Identify materials for patching leaks in condensers.
6. Identify types and styles of air-cooled condensers.

**UNIT: 10 COMMERCIAL/INDUSTRIAL AIR CONDITIONING**

**LEARNING OUTCOME:**

10.5 Replace an air-cooled condenser.

**TASK:**

10.5.1 Replace air-cooled condenser.

**PERFORMANCE STANDARD:**

Condenser must be level and mechanically secure. Refrigerant lines must be mechanically secure and leakproof. All electrical connections must be mechanically secure and in accordance with wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, refrigerant, replacement condenser

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Attach gauges.
3. Discharge refrigerant.
4. Remove air-cooled condenser.
5. Place new condenser and connect hot gas and liquid lines.
6. Leak test.
7. Install new drier.
8. Evacuate system.
9. Charge system.
10. Leak test.
11. Restore power to unit.
12. Start unit and check air flow across condenser and head pressure.
13. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify the function of air-cooled condenser.
3. Identify types and styles of condensers.
4. Describe how to purge, evacuate and charge refrigeration unit.
5. Identify types of refrigerant.
6. Identify cause of condenser failure.

**UNIT: 10      COMMERCIAL/INDUSTRIAL AIR CONDITIONING**

**LEARNING OUTCOME:**

10.6 Balance an evaporator for adequate air flow.

**TASK:**

10.6.1 Balance evaporator for adequate air flow.

**PERFORMANCE STANDARD:**

Air flow must match manufacturer's recommended volume.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, air velocity meter, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Attach gauges.
2. Measure air flow through ducts.
3. Measure current draw of evaporator fan motor.
4. Determine that system is fully charged.
5. Adjust fan motor speed to maximum efficiency (minimum current draw) while remaining within tolerances of air volume and evaporator temperature.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how to use air measuring equipment.
3. Determine amount of air flow.
4. Demonstrate use of incline manometer.
5. Demonstrate use of air velocity indicator gauge.
6. Determine cubic/feet/minute air flow of unit.

**UNIT: 11      COMMERCIAL REFRIGERATION**

**LEARNING OUTCOME:**

11.1    Adjust the superheat.

**TASK:**

11.1    Adjust superheat.

**PERFORMANCE STANDARD:**

Superheat must be within limits as specified by manufacturer of equipment.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gauges, manufacturer's specifications, thermometer

**PERFORMANCE STEPS:**

1.    Attach gauges.
2.    Connect clamp-on thermometer to suction line at evaporator outlet.
3.    Record suction pressure with unit in operation.
4.    Add 2 psi to suction pressure.
5.    NOTE: Estimated suction line pressure drop.
5.    Subtract this number from reading of thermometer to determine superheat.

**ENABLING OBJECTIVES:**

1.    Explain relevant safety practices and procedures.
2.    Define superheat.
3.    Identify superheat adjustment.
4.    Explain use of gauge and manifold set.
5.    Explain how to measure refrigerant line temperatures.
6.    Explain how to adjust superheat.

**UNIT: 11      COMMERCIAL REFRIGERANT**

**LEARNING OUTCOME:**

11.2    Service a hot gas defrost system.

**TASK:**

11.2.1    Service hot gas defrost system.



**PERFORMANCE STANDARD:**

Unit must defrost evaporator when condition dictates.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Remove service panel.
2. Inspect and clean air passage areas.
3. Test circulating system.
4. Check heat source.
5. Cycle system and test operation.
6. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Determine location of hot gas line, hot gas solenoid, defrost timer, defrost termination thermostat.
3. Explain how hot gas defrost works.
4. Explain need for defrosting.

**UNIT: 11      COMMERCIAL REFRIGERATION**

**LEARNING OUTCOME:**

11.3 Install a pump down control system.

**TASK:**

11.3.1 Install pump down control system.

**PERFORMANCE STANDARD:**

System must pump down on the off cycle.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's installation manual

**PERFORMANCE STEPS:**

1. Read manufacturer's manual.
2. Determine best location for system.
3. Purge system.
4. Top system at points specified by manufacturer.
5. Connect required tubing.
6. Install wiring following manufacturer's specifications.

7. Evacuate and recharge system.
8. Attach gauges.
9. Adjust pump down control to specifications.
10. Cycle system and test.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain advantages of pump down system.
3. Explain operating sequence of pump down system.
4. Determine location of liquid line solenoid valve.

**UNIT: 11      COMMERCIAL REFRIGERATION**

**LEARNING OUTCOME:**

- 11.4 Evacuate and charge a commercial refrigeration system.

**TASK:**

- 11.4.1 Evacuate and charge commercial refrigeration system.

**PERFORMANCE STANDARD:**

System must maintain temperature and pressure within two degrees and 5 psi of manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gauges, manufacturer's specifications, refrigerant, vacuum pump

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Attach gauges.
3. Purge system of refrigerant.
4. Connect vacuum pump.
5. Operate vacuum pump 15-30 minutes.
6. Check vacuum with vacuum gauge.
7. Observe vacuum gauge for indications of system leakage.
8. Recharge system.  
NOTE: When air and moisture content are within prescribed limits -29.95" -29.9" Hg.
9. Restore power to unit.
10. Start system and check operation.
11. Leak test.
12. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain methods of charging.
3. Identify various refrigerants and their proper use.
4. Determine application design temperatures and pressures components.
5. Identify service valves, sight glass and all components.
6. Describe use of vacuum pump.
7. Describe use of gauges and manifold set.
8. Describe use of dry nitrogen.
9. Describe use of temperature pressure chart.

**UNIT: 11      COMMERCIAL REFRIGERATION**

**LEARNING OUTCOME:**

11.5 Adjust the high and low pressure controls of a commercial system.

**TASK:**

11.5.1 Adjust high and low pressure controls of commercial system.

**PERFORMANCE STANDARD:**

High and low pressure controls must be adjusted to tolerances specified by manufacturer.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gauges, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Remove service panel.
2. Attach gauges.
3. Cycle system.
4. Observe gauge readings.
5. Adjust controls as to operate system to manufacturer's specified pressure.
6. Cycle system and verify readings.
7. Remove gauges.
8. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types and styles of gauges.
3. Identify function of high and low pressure controls.

4. Describe effects of malfunctioning limit control on air conditioning system.
5. Identify causes of limit control malfunction.

**UNIT: 11 COMMERCIAL REFRIGERATION**

**LEARNING OUTCOME:**

11.6 Replace a defrost heater.

**TASK:**

11.6.1 Replace defrost heater.

**PERFORMANCE STANDARD:**

Defrost heater must be mechanically secure and be wired in accordance with wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, ohmmeter, replacement heater

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove breaker strips to locate heater.
3. Isolate and check circuit with ohmmeter.
4. Locate defrost heater and remove.
5. Identify and tag wires.
6. Install replacement defrost heater.
7. Connect unit to power source.
8. Start unit.
9. Place unit in defrost and check amperage draw.
10. Stop unit.
11. Replace breaker strips.
12. Reinstall cabinet parts.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify function of defrost heater.
3. Describe how defrost heater operates.
4. Explain how to set up and connect ohmmeter.
5. Identify causes of defrost heater malfunction.

**UNIT: 11      COMMERCIAL REFRIGERATION**

**LEARNING OUTCOME:**

11.7 Replace/repair refrigeration tubing.

**TASK:**

11.7.1 Replace/repair refrigeration tubing.

**PERFORMANCE STANDARD:**

Refrigeration tubing must be replaced or repaired and be of size specified by manufacturer and leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, refrigerant, refrigerant tubing

**PERFORMANCE STEPS:**

1. Disconnect system from power source.
2. Discharge refrigerant.
3. Locate tubing to be repaired.
4. Determine if repairs are practical or replacement is required.
5. Disconnect tubing.
6. Replace and secure as required.
7. Evacuate and recharge system.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe procedure for discharging refrigerant.
3. Describe procedure for evacuating and charging refrigeration systems.
4. Identify types of refrigeration tubing.
5. Differentiate between ID and OD of tubing.

**UNIT: 11      COMMERCIAL REFRIGERATION**

**LEARNING OUTCOME:**

11.8 Braze joints.

**TASK:**

11.8.1 Braze joints.

**PERFORMANCE STANDARD:**

Brazed joint must be mechanically secured, leakproof and must be free of flux.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Brazing equipment, flux, sand cloth, wiping cloth

**PERFORMANCE STEPS:**

1. Clean joint with sand cloth.
2. Apply flux to joint sparingly.
3. Apply heat to joint.
4. Bring temperature of joint to melting point for brazing filler being used.
5. Apply filler rod to joint.
6. Cool joint.
7. Remove excess flux.
8. Pressure or leak test joint.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types of brazing filler rods.
3. Identify cleaning techniques for removing flux.
4. Identify the function of flux.
5. Identify types of fluxes.
6. Explain how to set up brazing equipment.

**UNIT: 11      COMMERCIAL REFRIGERATION**

**LEARNING OUTCOME:**

11.9 Repair or replace a solenoid valve.

**TASK:**

11.9.1 Repair or replace solenoid valve.

**PERFORMANCE STANDARD:**

Replaced solenoid valve and electrical connections must be mechanically secure and installed in accordance with wiring diagram and/or manufacturer's specifications. All connections must be leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, refrigerant, replacement valve, vacuum pump



**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Attach gauges.
3. Discharge refrigerant or pump system down.
4. Remove defective solenoid valve.
5. Solder/braze new valve in place.
6. Leak test and install drier.
7. Evacuate system.
8. Connect wires from solenoid to power source.
9. Charge system to full sight glass.
10. Operate solenoid several times to assure blocking of refrigerant flow.
11. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how solenoid valve operates.
3. Identify causes of solenoid valve malfunction.
4. Explain effects of malfunctioning solenoid valve on operation of system.
5. Explain how to purge, evacuate and charge refrigerant system.

**UNIT: 11      COMMERCIAL REFRIGERATION**

**LEARNING OUTCOME:**

11.10 Check duct system for air circulation.

**TASK:**

11.10.1 Check duct system for air circulation.

**PERFORMANCE STANDARD:**

Measured air circulation must be within tolerances specified by manufacturer.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, velocity meter

**PERFORMANCE STEPS:**

1. Inspect complete system.
  - a. Locate all ducts.
  - b. Locate openings.
  - c. Locate dampers.
2. Open all dampers in ducts and at grilles.
3. Check velocities at each outlet.

4. Determine free grille area.
5. Calculate volume of air flow per minute at each outlet.  
 NOTE:  $\frac{\text{Area in sq. in.}}{\text{fpm} \times 144} \times \text{cu. ft./min.} = (\text{Volume per minute})$

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types of meters for measuring velocity.
3. Identify causes of poor air movement within duct system.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.1 Determine temperature rise across a furnace.

**TASK:**

12.1.1 Determine temperature rise across furnace.

**PERFORMANCE STANDARD:**

Measured and rated input must be approximately the same.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, furnace unit

**PERFORMANCE STEPS:**

1. Turn off all other gas appliances.
2. Start furnace.
3. At gas meter determine number of seconds required for test meter dial to complete one revolution.
4. Calculate temperature rise from formula:  

$$\frac{3600 \text{ no. seconds in hour}}{\text{No. seconds per revolution}} \times \text{Dial size} \times \text{Heat value of gas} = \text{BTU Input}$$
5. Compare calculated to rated input of unit.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify possible solutions if input readings are not similar.
3. Explain procedure for LP gas units.
4. Define term "BTU."

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.2 Determine gas pressure of a furnace.

**TASK:**

12.2.1 Determine gas pressure of furnace.

**PERFORMANCE STANDARD:**

Reading on manometer must be between 3.5 and 4 inches of water column on natural gas or between 10 and 11 inches of water column on LP gas.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manometer, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Shut off gas to unit.
2. Attach manometer.
3. Measure gas pressure.
4. Remove manometer.
5. Compare reading to manufacturer's specifications.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain reason for checking pressure.
3. Identify location of pressure taps.
4. Demonstrate use of U tube manometer.
5. Explain step to adjust pressure of pressure regulator.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.3 Remove and replace a fan-limit control.

**TASK:**

12.3.1 Remove and replace fan-limit control.

**PERFORMANCE STANDARD:**

Fan-limit control must turn fan off and on and limit must be adjusted so heat exchanger temperature does not exceed 200 degrees.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, fan limit control, manufacturer's specifications, wiring diagram

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove service panel.
3. Disconnect wires.
4. Remove control switch.
5. Position replacement control switch.
6. Make electrical connections in accordance with wiring diagram.
7. Connect unit to power source.
8. Start unit.
9. Test operation.
10. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. State purpose of fan limit control.
3. Determine location of fan-limit controls.
4. Explain results of improperly adjusted or bad controls.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.4 Remove and replace a gas valve.

**TASK:**

12.4.1 Remove and replace gas valve.

**PERFORMANCE STANDARD:**

Valve must open when voltage is applied. Valve must close when voltage is removed, and pilot must remain lit. Joints must be leakproof and electrical connections tight and secure.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gas valve, soap solution

**PERFORMANCE STEPS:**

1. Turn off gas supply and disconnect.
2. Remove gas valve.

3. Compare old valve with new valve.
4. Install new valve.
5. Connect gas supply and pressurize.
6. Leak test with soap solution.
7. Light pilot.
8. Cycle furnace.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain purpose of gas valve.
3. Identify types of gas valves.
4. Make electrical connections.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.5 Remove and replace a transformer.

**TASK:**

12.5.1 Remove and replace transformer.

**PERFORMANCE STANDARD:**

Transformer must be securely attached, wires firmly connected, wired according to manufacturer's specifications and unit working correctly.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, replacement transformer

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Locate transformer.
3. Remove wires from transformer (label wires).
4. Remove transformer.
5. Mount replacement transformer.
6. Connect wires to transformer.
7. Connect unit to power source.
8. Start unit.
9. Check transformer operation.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain purpose of transformer.

3. Determine location of transformer.
4. Identify primary and secondary windings.
5. Identify techniques for making electrical connections.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.6 Remove and replace room thermostats.

**TASK:**

12.6.1 Remove and replace room thermostats.

**PERFORMANCE STANDARD:**

Temperature control subbase must be mechanically secure and level. All electrical connections must be secure and in accordance with wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, level, manufacturer's specifications, thermostat, wiring schematic

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove cover from control.
3. Remove mount screws from control.
4. Disconnect electrical wires from control subbase.
5. Remove subbase from wall and discard.
6. Mount new control subbase.
7. Level new control subbase.
8. Connect electrical wires to subbase.
9. Mount new control on subbase.
10. Replace cover.
11. Restore power to unit.
12. Start unit and check operation.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types of wall thermostats.
3. Determine location of wall thermostats.
4. Explain procedure for leveling thermostat.
5. Explain how thermostats are constructed and work.



**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.7 Remove and replace a blower and motor.

**TASK:**

12.7.1 Remove and replace blower and motor.

**PERFORMANCE STANDARD:**

Blower and motor must be securely in place, electrical connection must be secure, and belt must be adjusted to allow movement of one inch in center of longest span.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, replacement blower and motor

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove access panels to gain access to blower unit.
3. Loosen motor mounting system.
4. Remove belt and electrical connection.
5. Remove motor and blower unit.
6. Install blower and motor unit.
7. Secure blower mounting system.
8. Align belt.
9. Adjust tension.
10. Secure motor in position.
11. Connect electrical connection.
12. Test run unit.
13. Replace access panels.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain procedure for adjusting belt tension.
3. Identify electrical connections.
4. Identify types of motors.
5. Identify sizes of motors.
6. Identify color codes and wire connectors.
7. Explain procedure for checking motor mountings.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.8 Install and service a high efficiency gas furnace.

**TASK:**

12.8.1 Install and service high efficiency gas furnace.

**PERFORMANCE STANDARD:**

Furnace must be installed and serviced according to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, furnace unit, manufacturer's installation manual

**PERFORMANCE STEPS:**

1. Read manufacturer's installation manual.
2. Locate position of furnace.
3. Level furnace.
4. Align plenum with ductwork and secure.
5. Connect vent to chimney.
6. Run gas pipe to unit and connect.
7. Install electrical cable to unit.
8. Install thermostat control.
9. Connect furnace to power.
10. Test cycle furnace.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify requirements for gas piping.
3. Identify pipe sizes and fittings available.
4. Differentiate between high energy efficient furnaces and standard furnaces.
5. Describe types/styles of thermostats available.
6. Explain how to calculate size of furnace.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.9 Wire a complete gas heating system.

**TASK:**

12.9.1 Wire complete gas heating system.

**PERFORMANCE STANDARD:**

Wires must be connected according to manufacturer's specifications, tight and secure. Unit must work as designed.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, gas heating system, manufacturer's specifications, National Electrical Code specifications, wiring schematic

**PERFORMANCE STEPS:**

1. Read manufacturer's installation manual.
2. Install thermostat and wire by color code.
3. Connect thermostat controls to furnace using manufacturer's color code.
4. Run cable from fuse box to service switch using National Electrical Code specifications.
5. Connect power from service to furnace components using manufacturer's specifications.
6. Power up system.
7. Test operate unit.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
1. Explain the use of schematics.
2. Identify wiring terminals.
3. Explain operating sequence of a gas furnace.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.10 Repair or replace a solenoid valve.

**TASK:**

12.10.1 Repair or replace solenoid valve.

**PERFORMANCE STANDARD:**

Solenoid valve must be mechanically secure. All electrical connections must be secure and in accordance with wiring diagram and/or manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, ohmmeter, manufacturer's specifications, replacement coil, solenoid valve, wire connectors, wiring diagram

**PERFORMANCE STEPS:**

1. Disconnect unit from power supply.
2. Locate defective pilot solenoid valve coil.

3. Disconnect solenoid wires.
4. Remove solenoid.
5. Test resistance.
6. Compare defective coil with replacement coil.
7. Install replacement coil.
8. Connect wires.
9. Restore power to unit.
10. Test operation.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe how a solenoid valve functions.
3. Identify different types of solenoid valves and their applications.
4. Explain how to connect and read an ohmmeter.
5. Define the terms open, short and ground.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.11 Adjust burners.

**TASK:**

12.11.1 Adjust burners.

**PERFORMANCE STANDARD:**

Burner and flame ports must be free of dust and rust. Flame must be soft blue and not lift from burner.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit

**PERFORMANCE STEPS:**

1. Disassemble furnace.
2. Remove dust and rust from burner.
3. Clean flame ports.
4. Reassemble furnace.
5. Light pilot.
6. Fire off furnace.
7. Observe flame.
8. Adjust primary air as needed.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify flame ports.
3. Describe procedure for cleaning flame ports.
4. Define the term "primary air."

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.12 Adjust a gas regulator valve.

**TASK:**

12.12.1 Adjust gas regulator valve.

**PERFORMANCE STANDARD:**

Gas pressure regulator must be adjusted to manufacturer's specifications and must be leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manometer, manufacturer's specifications, soap solution

**PERFORMANCE STEPS:**

1. Attach manometer.
2. Measure gas pressure.
3. Set gas pressure to manufacturer's specifications.
4. Remove manometer.
5. Leak test.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe how to connect and operate manometer.
3. Describe function of gas regulator valve.
4. Identify causes of regulator valve failure.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.13 Light and adjust a pilot.

**TASK:**

12.13.1 Light and adjust pilot.

**PERFORMANCE STANDARD:**

Pilot must stay lit when bypass is released and must be adjusted to soft blue flame.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit

**PERFORMANCE STEPS:**

1. Make sure gas is off.  
NOTE: Wait 5 minutes.
2. Turn on gas.
3. Depress gas safety by-pass.
4. Put lighted match to pilot assembly.
5. Hold by-pass open 60 seconds after pilot is lit.
6. Release by-pass.
7. Adjust pilot to soft blue flame.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe necessity of five minute waiting period before attempting to light unit.
3. Identify function of pilot light.
4. Identify function and operation of thermocouple.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.14 Determine the size unit needed for a given space.

**TASK:**

12.14.1 Determine size of unit needed for given space.

**PERFORMANCE STANDARD:**

Size of furnace for given area must be calculated to provide adequate heating.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Paper/pencil, reference charts, structure to be calculated



**PERFORMANCE STEPS:**

1. Determine length, width and height of structure.
2. Calculate square footage for exterior wall, interior wall, ceiling, floor, windows and door.
3. Classify building material of structure and amount of insulation in walls, ceiling and floor.
4. From reference chart calculate BTU of heat loss using data from steps 2 and 3.
5. Determine heat loss for windows and doors area.
6. Total heat losses and select furnace by matching calculated BTU with furnace units available.

**ENABLING OBJECTIVES:**

1. Identify types of building materials.
2. Explain heat loss calculations.
3. Explain insulation R factors.
4. Define the term "British Thermal Unit."

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.15 Check a heat exchanger.

**TASK:**

12.15.1 Check heat exchanger.

**PERFORMANCE STANDARD:**

Heat exchanger must be inspected for burn through and leakage.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit

**PERFORMANCE STEPS:**

1. Remove service panel.
2. Disconnect unit from power source and gas supply.
3. Dismantle furnace.
4. Remove heat exchanger.
5. Examine exchanger for burn through and holes.
6. Repair or replace damaged exchange.
7. Position exchanger.
8. Align screw holes and insert screws.
9. Assemble furnace.

10. Connect gas and pressure test for leaks.
11. Connect electrical supply.
12. Light pilot.
13. Test run unit.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe function and operation of heat exchanger.
3. Identify materials used to manufacture heat exchangers.
4. Identify causes of exchanger malfunction or damage.
5. Describe how to test gas system for leaks.
6. Identify dangers of operating furnace with defective heat exchange chamber.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.16 Check a system for leaks and repairs.

**TASK:**

12.16.1 Check system for leaks and repairs.

**PERFORMANCE STANDARD:**

All leaks in furnace system must be located and appropriate repairs must be specified.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, carbon monoxide sensor, pipe dope, soap and water solution

**PERFORMANCE STEPS:**

1. Soap pipe joints and fittings.
2. Inspect for bubbles at joints and fittings.
3. Tighten fittings to stop leak.  
NOTE: It may be necessary to take fitting apart and coat male threads with pipe dope and reassemble to stop leaks.
4. Use carbon monoxide sensor on output register to check for leaks in heat exchanger.
5. Use carbon monoxide sensor on flue pipe to test for excess leakage.
  - a. Replace flue pipe if leak detected.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify safety hazards of operating system with gas or carbon monoxide leaks.
3. Identify causes of leaks in gas pipe.
4. Describe effects of carbon monoxide poisoning.

**UNIT: 12      GAS HEATING**

**LEARNING OUTCOME:**

12.17 Install belts.

**TASK:**

12.17.1 Install belts.

**PERFORMANCE STANDARD:**

Belt(s) must be aligned and adjusted to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, furnace, replacement belt

**PERFORMANCE STEPS:**

1. Remove service panel.
2. Disconnect motor from power source.
3. Loosen belt adjustment.
4. Inspect pulleys.
5. Install belt.
6. Align and adjust belt tension.
7. Tighten adjustment system.
8. Restore power to unit.
9. Start motor.
  - a. Check belt alignment and tension.
10. Shut off motor.
11. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types and styles of belts.
3. Explain how belts are sized.
4. Identify causes of belt failure.
5. Describe effect of over-tightening belt tension.

UNIT: 13 OIL HEATING

LEARNING OUTCOME:

13.1 Service fuel oil gun burners.

TASK:

13.1.1 Service fuel oil gun burners.

PERFORMANCE STANDARD:

Fuel oil gun burner must be cleaned and adjusted to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, fuel oil gun burner

PERFORMANCE STEPS:

1. Disconnect unit from power source.
2. Disconnect electrical connections from motor.
3. Disconnect and plug oil feed line.
4. Remove gun burner.
5. Dismantle gun burner.
6. Clean jets and components.
7. Assemble gun burner.
8. Center spray nozzle carefully.
9. Align and gap electrodes.
10. Secure gun burner in position.
11. Connect fuel line.
12. Connect unit electrically.
13. Turn unit on.
14. Adjust flame and ingitor to manufacturer's specifications.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify types of oil burner guns.
3. Identify major components of gun burner.
4. Describe characteristics of malfunctioning gun burner.
5. Describe the color of a properly adjusted flame in an oil burner.

UNIT: 13 OIL HEATING

LEARNING OUTCOME:

13.2 Install oil lines and filter.

**TASK:**

13.2.1 Install oil lines and filter.

**PERFORMANCE STANDARD:**

Oil lines and filter system must not leak fuel oil.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, fittings, tubing

**PERFORMANCE STEPS:**

1. Shut off fuel oil on tank valve.
2. Remove damaged line or filter.
3. Select fittings for type of piping or tubing being installed.
4. Cut tubing to desired length.
5. Slide fitting onto tubing.
6. Flare fitting or use compression fitting.
7. Tighten fittings to tubing.
8. Turn on main valve.
9. Inspect for leaks.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify techniques for connecting tubing.
3. Describe types of fittings available for tubing.
4. Explain function of filter in oil system.
5. Identify types of oil pumps.

**UNIT: 13 OIL HEATING**

**LEARNING OUTCOME:**

13.3 Service primary controls.

**TASK:**

13.3.1 Service primary controls.

**PERFORMANCE STANDARD:**

Primary controls must be serviced according to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, ohmmeter, voltmeter

#### PERFORMANCE STEPS:

1. Read manufacturer's specifications.
2. Disconnect unit from power.
3. Test circuits for continuity, resistance values, shorts and opens.
4. Connect to power source.
5. Test voltage drops at terminals specified by manufacturer.

#### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Describe how to set up, connect and read ohmmeter.
3. Describe how to connect and read voltmeter.
4. Explain how ignition igniter operates.
5. Define terms open, short, resistance and continuity.

#### UNIT: 13 OIL HEATING

#### LEARNING OUTCOME:

- 13.4 Check combustion efficiency of a furnace.

#### TASK:

- 13.4.1 Check combustion efficiency of furnace.

#### PERFORMANCE STANDARD:

Combustion efficiency must be determined and compared to manufacturer's specifications.

#### TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, carbon dioxide analyzer, efficiency charts, manufacturer's specifications, thermometer

#### PERFORMANCE STEPS:

##### Carbon dioxide analysis of flue gases

1. Start system.
2. Place carbon dioxide analyzer into flue stack.  
**NOTE:** Reading should be 10% to 12% CO<sub>2</sub>, without visible smoke.
3. Low reading indicates excess air.
4. Higher reading indicates lack of air.



### Temperature of flue gas

1. Start system.
  - a. Operate 15 minutes.
2. Insert thermometer into flue.
3. Measure temperature.
4. Compare reading to efficiency charts.

### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Describe function of carbon dioxide analyzer.
3. Explain effects of operating inefficient system.
4. Describe effect of H<sub>2</sub>SO<sub>4</sub> (sulphurous acid).
5. Identify types and styles of high temperature thermometers.

### UNIT: 14 ELECTRIC HEATING

#### LEARNING OUTCOME:

14.1 Determine air flow and temperature rise across electric furnace.

#### TASK(S):

- 14.1.1 Determine air flow across electric furnace.
- 14.1.2 Determine temperature rise across electric furnace.

#### TASK:

14.1.1 Determine air flow across electric furnace.

#### PERFORMANCE STANDARD:

Air flow must be measured, compared to manufacturer's specifications and necessary corrections made.

#### TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, anemometer/velocimeter

#### PERFORMANCE STEPS:

1. Start unit blower system.
2. Open all grills and dampers.
3. Measure velocity at each grill.
4. Measure free grill area.
5. Calculate volume at each outlet (fpm x area in sq. in. use).
6. Total all outlet volumes. 144
7. Compare calculated cubic feet per minute with manufacturer's specifications.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how to read velocimeter.
3. Compare an anemometer and a velocimeter.
4. Explain how to determine system balancing.
5. Identify techniques for correcting systems with improper air flow.

**UNIT: 14      ELECTRIC HEATING**

**LEARNING OUTCOME:**

14.1 Determine air flow and temperature rise across an electric furnace.

**TASK:**

14.1.2 Determine temperature rise across electric furnace.

**PERFORMANCE STANDARD:**

Measured temperatures must be within tolerances specified by manufacturer.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, thermometer

**PERFORMANCE STEPS:**

1. Position thermometer in cool air return.
  - a. Record reading.
2. Position thermometer in plenum.
3. Cycle unit to obtain plenum temperature.
  - a. Record reading.
4. Position thermometer at discharge point.
5. Cycle unit and record output temperature.
6. Compare measured readings with manufacturer's specifications.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how to measure temperature with a thermometer.
3. Explain where measurements are taken.
4. Determine manufacturer's design specifications.

**UNIT: 14 ELECTRIC HEATING**

**LEARNING OUTCOME:**

14.2 Determine voltage to heating element.

**TASK:**

14.2.1 Determine voltage to heating element.

**PERFORMANCE STANDARD:**

Voltage reading must be within 10 percent of manufacturer's rated voltage.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, heating element, manufacturer's specifications, voltmeter

**PERFORMANCE STEPS:**

1. Remove service panel.
2. Locate terminals of heating element.
3. Connect voltmeter leads.
4. Start unit.
5. Measure voltage drop at terminals.
6. Turn unit off.
7. Compare measured reading with manufacturer's specifications.
8. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain the use of a voltmeter.
3. Identify heating elements.
4. Determine rated voltage.
5. Define the term "voltage drop."
6. Identify causes of heating element malfunction.
7. Explain handling procedures for heating elements.

**UNIT: 14 ELECTRIC HEATING**

**LEARNING OUTCOME:**

14.3 Test voltage and wattage of heating element.

**TASK:**

14.3.1 Test voltage and wattage of heating element.

**PERFORMANCE STANDARD:**

Voltage and wattage of heating element must be measured to within 10 percent of manufacturer's ratings.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, heating element, manufacturer's specifications, voltmeter, wattmeter

**PERFORMANCE STEPS:**

1. Remove service panel.
2. Locate terminals of heating element.
3. Disconnect unit from power supply.
4. Wire in voltmeter and wattmeter.
5. Connect power supply.
6. Operate system.
7. Record readings on meters.
8. Shut down system.
9. Disconnect power source.
10. Remove meter system.
11. Reconnect power to unit.
12. Test run unit.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain how to set up and read voltmeter.
3. Describe how to use ammeter in place of wattmeter.
4. Differentiate between start-up current draw and operating current.
5. Explain how to calculate wattage from voltage and amperage readings.
6. Identify possible reasons for differences between measured reading and manufacturer's ratings.

**UNIT: 14 ELECTRIC HEATING**

**LEARNING OUTCOME:**

- 14.4 Inspect sequencing and safety devices.

**TASK:**

- 14.4.1 Inspect sequencing and safety devices.

**PERFORMANCE STANDARD:**

Sequencing and safety devices must control elements as per manufacturer's design.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Read manufacturer's specifications.
2. Remove service panel.
3. Inspect electrical connections.
4. Compare wiring color code to specifications.
5. Cycle system to verify operation of components.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain purpose of safety devices.
3. Determine location of safety devices.
4. Explain purpose of sequencer.
5. Identify location and types of sequencers.
6. Explain how to test sequencer.
7. Describe harmful effects of low air movement across heating element.

**UNIT: 14 ELECTRIC HEATING**

**LEARNING OUTCOME:**

14.5 Inspect blowers and motors.

**TASK:**

14.5.1 Inspect blowers and motors.

**PERFORMANCE STANDARD:**

Blower and motor must deliver CFM of air specified by manufacturer and must operate at rated RPM.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, anemometer, ohmmeter, tachometer

**PERFORMANCE STEPS:**

1. Remove service panel.
2. Disconnect unit from power source.
3. Clean and inspect blower fins.
4. Check bearings for lubrication.
5. Position anemometer.
6. Connect unit power.
7. Cycle system.

8. Record reading on anemometer.
9. Place tachometer on shaft of motor and record RPM.
10. Compare measured reading to manufacturer's specifications.
11. Remove anemometer.
12. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain use of ohmmeter.
3. Explain procedure for adjusting belt tension.
4. Determine location of blower and motor.
5. Explain how to clean blower and motor.
6. Identify styles of tachometers.

**UNIT: 14 ELECTRIC HEATING**

**LEARNING OUTCOME:**

- 14.6 Determine sizes needed for electric baseboard heat.

**TASK:**

- 14.6.1 Determine sizes needed for electric baseboard heat.

**PERFORMANCE STANDARD:**

Size of electric baseboard heater must be calculated to provide adequate heating.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Paper/pencil, reference charts, structure to be calculated

**PERFORMANCE STEPS:**

1. Determine length, width and height of structure.
  2. Calculate square footage for:
    - a. Exterior wall
    - b. Interior wall
    - c. Ceiling
    - d. Floor
    - e. Windows
    - f. Door
  3. Classify structure's building material.
  4. Classify amount of insulation in:
    - a. Walls
    - b. Ceiling
    - c. Floor
  5. Calculate BTU of heat loss using data from steps 2 and 4.
- NOTE: Use reference charts.



6. Determine heat loss for doors and windows.
7. Total heat losses.
8. Convert BTU into watts.  
NOTE: 1 watt = 3.415 BTU.
9. Select baseboard heater based on wattage required.

**ENABLING OBJECTIVES:**

1. Identify types of building material.
2. Explain insulation R factor.
3. Define the term "British Thermal Unit."

**UNIT: 14 ELECTRIC HEATING**

**LEARNING OUTCOME:**

- 14.7 Install baseboard heat with thermostat.

**TASK:**

- 14.7.1 Install baseboard heat in thermostat.

**PERFORMANCE STANDARD:**

Baseboard heater must be securely attached to wall, level and wired according to manufacturer's specifications and National Electrical Code requirements.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, baseboard heater, manufacturer's installation instructions, National Electrical Code

**PERFORMANCE STEPS:**

1. Read manufacturer's instructions to determine size of cable and breaker.
2. Install cable from breaker box to location of baseboard heater.
3. Locate position of thermostat.
4. Install thermostat wiring.
5. Position, secure and wire thermostat as per manufacturer's specifications.
6. Position level and secure heating unit to wall.
7. Connect wiring to heating unit.
8. Connect cable to breaker box.
9. Test operate unit.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain relevant sections of the National Electrical Code.
3. Identify advantages and disadvantages of baseboard heating.
4. Describe techniques for securing heaters to walls.
5. Identify problems that might arise when installing baseboard heater in existing structure.
6. Explain how to calculate entrance cable size.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRAONICS**

**LEARNING OUTCOME:**

- 15.1 Install a heat pump.

**TASK:**

- 15.1.1 Install heat pump.

**PERFORMANCE STANDARD:**

Unit must be installed according to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, complete heat pump system, manufacturer's installation instructions

**PERFORMANCE STEPS:**

1. Read manufacturer's instruction manual.
2. Determine location of interior components.
3. Determine location of exterior components.
4. Install exterior components, level and secure as specified by manufacturer.
5. Install interior components, level and secure as specified by manufacturer.
6. Interconnect interior and exterior components.
7. Connect system electrically.
8. Purge and charge system if required.
9. Cycle system.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types/styles of heat pump systems.
3. Identify major components of heat pump.

4. Describe advantages and disadvantages of heat pump.
5. Describe how heat pump functions.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.2 Install/service supplementary heat strips.

**TASK:**

15.2.1 Install/service supplementary heat strips.

**PERFORMANCE STANDARD:**

Supplementary heat strips must be wired according to specifications. Heat strips must pull current as specified by manufacturer.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, ohmmeter, system with heater strips, voltmeter

**PERFORMANCE STEPS:**

1. Read manufacturer's service manual.
2. Locate access service panel for heater strip.
3. Remove access panel.
4. Disconnect heater from power supply.
5. Check heater strip for continuity, resistance, shorts, and grounds.
6. Compare measured reading with manufacturer's specifications.
7. Reconnect heater to power supply.
8. Cycle system.
9. Measure voltage drops and compare to manufacturer's specifications.
10. Replace access panel.

**ENABLING OBJECTIVES**

1. Explain relevant safety practices and procedures.
2. Identify function of heater strips.
3. Explain how heater strips operate.
4. Identify causes of heater strip failure.
5. Explain how to set up, connect and read ohmmeters and voltmeters.
6. Define terms current draw, resistance, short and ground.
7. Identify types of heater strips.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.3 Check heat pump controls.

**TASK:**

15.3.1 Check heat pump controls.

**PERFORMANCE STANDARD:**

Heat pump controls must be mechanically secured, wired and operating according to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, control system on heat pump, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove service panels.
3. Verify that wiring agrees with schematic.
4. Check connections for being secure.
5. Restore power to unit.
6. Test run unit on both heating and cooling cycles.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify various controls found on heat pumps.
3. Describe functions of various controls on heat pumps.
4. Describe how heat pump operates.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.4 Replace and adjust limit switches.

**TASK:**

15.4.1 Replace and adjust limit switches.

**PERFORMANCE STANDARD:**

Limit control switch must be mechanically secure, wired according to schematic and operating to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, limit control switch, manufacturer's specifications, wiring schematic

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Remove service panel.
3. Locate limit switch.
4. Remove wiring.
5. Remove switch from mount.
6. Secure replacement switch.
7. Install wires on control.
8. Connect unit to power source.
9. Test and adjust to manufacturer's specifications.
10. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe function of a limit control switch.
3. Describe how a limit control switch operates.
4. Identify types/styles of limit control switches.
5. Identify causes of limit switch malfunction.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.5 Check system for leaks and repair.

**TASK:**

15.5.1 Check system for leaks and repair.

**PERFORMANCE STANDARD:**

All leaks must be located and repaired.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing equipment, electronic leak detector, gauges, soap solution

**PERFORMANCE STEPS:**

1. Attach gauges.
2. Pressurize system.
3. Leak test by sniffing tubing and components with electronic detector or soap solution.



4. Tighten leaking fitting.

For faulty tubing:

- a. Purge system.
  - b. Clean area.
  - c. Braze or silver solder leak.
  - d. Clean flux.
  - e. Recharge system.
5. Retest system.
  6. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify cause of leaks.
3. Describe types of epoxy repair materials available.
4. Explain how to braze and silver solder.
5. Identify types of leak detectors.

**UNIT: 15      HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.6 Remove restrictions and adjust pressure of automatic valve expansion.

**TASK:**

15.6.1 Remove restrictions and adjust pressure of automatic valve expansion.

**PERFORMANCE STANDARD:**

Restrictions must be removed and pressure must be adjusted to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Attach gauges.
3. Discharge refrigerant.
4. Remove expansion valve.
5. Seal system.
6. Disassemble valve.
7. Clean strainer and orifice.
8. Assemble valve and replace.



9. Evacuate system.
10. Recharge.
11. Start unit and allow time for pressure to stabilize.
12. Turn adjustment clockwise to increase flow, counter-clockwise to decrease flow.
13. Set to manufacturer's specifications.
14. Replace adjustment cover.
15. Remove gauges.
16. Leak test.

#### ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Identify parts of expansion valve.
3. Describe how automatic expansion valve functions.
4. Identify purpose of expansion valve.
5. Identify causes of expansion valve failure.
6. Describe effects defective expansion valve has on operation of system.

UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS

#### LEARNING OUTCOME:

15.7 Correct restrictions in capillary tubes.

#### TASK:

15.7.1 Correct restrictions in capillary tubes.

#### PERFORMANCE STANDARD:

Restrictions must be removed from capillary tube.

#### TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, brazing outfit, capillary tube cleaner, leak detector

#### PERFORMANCE STEPS:

1. Attach gauges.
2. Purge system.
3. Unbrazed capillary tube.
4. Remove restrictions using capillary tube cleaner.
5. Replace capillary tube and braze.
6. Evacuate system.
7. Recharge system.
8. Leak test system.
9. Start system and check operation.
10. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe function of capillary tube.
3. Identify causes of capillary tube malfunction.
4. Describe effects defective capillary tubes have on operation of the system.
5. Explain how to purge, evacuate and charge heat pump.
6. Explain brazing procedures.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.8 Determine temperature rise and drop across coils.

**TASK:**

15.8.1 Determine temperature rise and drop across coils.

**PERFORMANCE STANDARD:**

Temperature rise must be 20 to 30 degrees on heating and drop between 12 and 15 degrees on cooling.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Heat pump unit, manufacturer's specifications, thermometer

**PERFORMANCE STEPS:**

1. Remove access panels.
2. Position thermometers.
3. Cycle unit.
4. Read and record thermometer readings.
5. Remove thermometers.
6. Replace access panels.
7. Compare reading to manufacturer's specifications.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Demonstrate measuring temperature with a thermometer.
3. Identify where measurements are taken.
4. Explain why rise and drop is important.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.9 Determine operating pressures.

**TASK:**

15.9.1 Determine operating pressures.

**PERFORMANCE STANDARD:**

High side temperature must be 30-35 degrees above ambient, pressures must be read from pressure chart. Low side pressure must correspond to coil temperature of 40 degrees.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, pressure gauges, thermometers

**PERFORMANCE STEPS:**

1. Determine ambient temperature.
2. Install gauges and manifold set.
3. Position thermometers.
4. Cycle unit.
5. Read and record gauges.
6. Read and record thermometers.
7. Compare reading with manufacturer's specifications.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Explain use of gauge and manifold set.
3. Explain pressure chart.
4. Explain purpose of service valves.
5. Define ambient temperature.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.10 Charge a heat pump.

**TASK:**

15.10.1 Charge heat pump.

**PERFORMANCE STANDARD:**

Heat pump must be charged to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, refrigerant

**PERFORMANCE STEPS:**

1. Read manufacturer's service manual.
2. Install gauges.
3. Connect refrigerant service cylinder to system.
4. Operate heat pump.
5. Open refrigerant cylinder valve.
6. Charge system to manufacturer's specifications.
7. Close refrigerant cylinder valves.
8. Shut down system.
9. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify gauges used in charging a heat pump.
3. Explain service valves' functions.
4. Identify type and amount of refrigerant.
5. Explain temperature pressure charts.
6. Identify all sealed system components.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.11 Inspect a reversing valve.

**TASK:**

15.11.1 Inspect reversing valve.

**PERFORMANCE STANDARD:**

Valve direct refrigerant flow correct direction for cooling and reverse flow for heating.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, thermometer

**PERFORMANCE STEPS:**

1. Remove access panels.
2. Locate reversing valve.
3. Position thermometer in coil.
4. Position valve in heating position.

5. Measure heat on coils.
6. Reverse valve to cooling position.
7. Measure cooling effect on coils.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types of four-way valves.
3. Determine location of reversing valves.
4. Explain use of ohmmeter.
5. Explain operating sequence of heat pump.

**UNIT: 15      HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.12 Remove and replace common defrost controls.

**TASK:**

15.12.1 Remove and replace common defrost controls.

**PERFORMANCE STANDARD:**

Defrost control must cycle when ice accumulates on coils and must terminate defrost cycle when ice has melted.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, defrost control

**PERFORMANCE STEPS:**

1. Remove service panel.
2. Locate defrost control.
3. Remove electrical service connectors.
4. Loosen and remove mounting screws.
5. Remove control unit.
6. Mount and secure control unit in position.
7. Connect electrical wiring.
8. Test operate system.
9. Replace service panel.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Describe types of defrost systems.
3. Describe types of defrost controls.
4. Explain purpose of defrost controls.

UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS

LEARNING OUTCOME:

15.13 Remove and replace outdoor.

TASK:

15.13.1 Remove and replace outdoor.

PERFORMANCE STANDARD:

Outdoor thermostat must operate according to manufacturer's specifications.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit, manufacturer's specifications, outside thermostat

PERFORMANCE STEPS:

1. Locate outside thermostat.
2. Remove cover plate.
3. Disconnect electrical wiring label wiring.
4. Remove mounting sub-base.
5. Install new sub-base
6. Connect wiring following wiring schematics.
7. Replace cover.
8. Cycle system.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
2. Explain purpose of outdoor thermostats.
3. Explain how to determine location of outdoor thermostats.
4. Identify types of outdoor thermostats.
5. Determine temperature setting.

UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS

LEARNING OUTCOME:

15.14 Wire heat pump thermostats.

TASK:

15.14.1 Wire heat pump thermostats.



**PERFORMANCE STANDARD:**

Thermostat must be level, plumb and wired according to manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications, thermostat, wiring schematic

**PERFORMANCE STEPS:**

1. Locate position of thermostat.
2. Install required wiring from heat pump to thermostat location.
3. Position, level, plumb and secure sub-base to wall.
4. Position and secure control unit.
5. Connect wiring as specified.
6. Install cover.
7. Test operate heat pump.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Determine ideal location.
3. Identify color code.
4. Explain mercury bulb-bimetal thermostats.
5. Describe low voltage circuit.
6. Explain schematic drawings.
7. Use level.

**UNIT: 15      HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.15 Determine temperature rise across a collector.

**TASK:**

15.15.1 Determine temperature rise across collector.

**PERFORMANCE STANDARD:**

Temperature rise across collector must be accurately measured.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, thermometers

**PERFORMANCE STEPS:**

1. Locate collector.
2. Position thermometer on input rise of collector.
3. Position second thermometer in collector.
4. Cycle system.
5. Record thermometer readings.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify types of thermometers.
3. Explain function of collector.

**UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.16 Inspect circulating pumps.

**TASK:**

15.16.1 Inspect circulating pumps.

**PERFORMANCE STANDARD:**

Circulating pump must be inspected for leakage and output of pump must meet specified GPM.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Locate pump.
2. Inspect for leaks.
3. Install pressure gauges.
4. Operate pump.
5. Record readings and compare to manufacturer's specifications.
6. Shut down pump.
7. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
1. Determine location of pumps.
2. Identify types of pumps.
3. Determine sizes of pumps.
4. Explain purpose of pumps.
5. Explain methods of testing.

UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS

LEARNING OUTCOME:

15.17 Test low water switches.

TASK:

15.17.1 Test low water switches.

PERFORMANCE STANDARD:

Low water switch must prevent operation of system when low water condition exists.

TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):

Standard tool kit

PERFORMANCE STEPS:

1. Locate low pressure switch.
2. Drain water from system to point at which system shuts down operation.
3. Check level with manufacturer's specifications.
4. Add water to system.
- NOTE: System should restart.
5. Fill system to specified level.

ENABLING OBJECTIVES:

1. Explain relevant safety practices and procedures.
1. Explain purpose of low water switch.
2. Identify types of low water switches.
3. Determine locations of switches.
4. Explain methods of testing.

UNIT: 15 HEAT PUMP, SOLAR AND HYDRONICS

LEARNING OUTCOME:

15.18 Replace automatic expansion valves.

TASK:

15.18.1 Replace automatic expansion valves.

**PERFORMANCE STANDARD:**

Automatic expansion valve must be mechanically secure and installed in accordance with manufacturer's specifications and must not leak.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, automatic expansion valve, manufacturer's specifications, refrigerant

**PERFORMANCE STEPS:**

1. Disconnect unit from power supply.
2. Attach gauges.
3. Discharge refrigerant.
4. Remove automatic expansion valve.
5. Secure new expansion valve.
6. Install drier.
7. Evacuate system.
8. Charge system with exact amount of refrigerant.
9. Leak test.
10. Restore power to unit.
11. Start system and operate 20 minutes.
12. Remove gauges.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify the function of an automatic expansion valve.
3. Describe how an automatic expansion valve operates.
4. Describe procedure for charging a system with refrigerant.
5. Explain how to test for leaks.

**UNIT: 15      HEAT PUMP, SOLAR AND HYDRONICS**

**LEARNING OUTCOME:**

15.19 Replace capillary tubes.

**TASK:**

15.19.1 Replace capillary tubes.

**PERFORMANCE STANDARD:**

Capillary tube must be mechanically secure and must be leakproof.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, brazing equipment, capillary tubing

**PERFORMANCE STEPS:**

1. Disconnect unit from power source.
2. Discharge refrigerant.
3. Unbrazed capillary tubing.
4. Remove capillary tubing.
5. Position new capillary tubing and secure.
6. Evacuate system.
7. Recharge system.
8. Leak test.
9. Restore power to unit.
10. Start system and check operation,.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Identify function of capillary tubing.
3. Describe effect of malfunctioning capillary tube on operation of unit.
4. Explain how to set up brazing equipment.
5. Describe techniques for leak testing.

**UNIT: 16 DEHUMIDIFIERS AND HUMIDIFIERS**

**LEARNING OUTCOME:**

16.1 Test humidistats.

**TASK:**

16.1.1 Test humidistats.

**PERFORMANCE STANDARD:**

Humidistat must maintain 35% to 40% relative humidity and be located 60 inches off floor and level.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit

**PERFORMANCE STEPS:**

1. Locate humidistat.
2. Remove cover.
3. Clean vent system in cover.
4. Clean and adjust contact points.
5. Replace cover.

**ENABLING OBJECTIVES:**

1. Explain types of humidity controls.
2. Determine the location of the humidistat.
3. Identify the adjustment screw on the humidistat.
4. Explain purpose and methods of control.
5. Explain the relevant safety precautions.

**UNIT: 16 DEHUMIDIFIERS AND HUMIDIFIERS**

**LEARNING OUTCOME:**

16.2 Install a humidifier and dehumidifier.

**TASK:**

16.2.1 Install humidifier and dehumidifier.

**PERFORMANCE STANDARD:**

Unit must be mechanically secure and connected in accordance with manufacturer's specifications.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, humidifier/dehumidifier unit, manufacturer's specifications

**PERFORMANCE STEPS:**

1. Locate position of unit.
2. Cut necessary access holes.
3. Position, level, plumb and secure main unit.
4. Position control unit.
5. Wire units together.
6. Connect water feeds and drains.
7. Test operate system.

**ENABLING OBJECTIVES:**

1. Explain relevant safety practices and procedures.
2. Differentiate between humidifier and dehumidifier.
3. Describe how humidifiers operate.
4. Describe how dehumidifiers operate.

**UNIT: 17 HEAT GAIN, HEAT LOSS AND DUCT DESIGN**

**LEARNING OUTCOME:**

17.1 Compute heat loss of a structure.



**TASK:**

17.1.1 Compute heat loss of structure.

**PERFORMANCE STANDARD:**

Heat loss for structure must be accurately calculated.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Blueprints/specifications, heat loss charts

**PERFORMANCE STEPS:**

1. Determine building materials involved.
2. Calculate square footage of:
  - a. Exterior wall.
  - b. Window.
  - c. Door heat loss.
3. Calculate ceiling heat loss.
4. Calculate heat loss of floor.
5. Calculate infiltration.
6. Determine temperature design.
7. Calculate BTU of heat loss using data calculated in steps 2-6.

**ENABLING OBJECTIVES:**

1. Define R and U factors.
2. Identify heat losses.
3. Describe effects of insulation.

**UNIT: 17 HEAT GAIN, HEAT LOSS AND DUCT DESIGN**

**LEARNING OUTCOME:**

17.2 Design and install duct system for structure as per blueprint specifications.

**TASK:**

17.2.1 Design and install duct system for structure as per blueprint specifications.

**PERFORMANCE STANDARD:**

Duct system must deliver air at designed temperature, CFM and velocity required for structure designated in blueprint.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Calculation charts, measuring tools

**PERFORMANCE STEPS:**

1. Determine design temperature.
2. Determine CFM and velocity required.
3. Calculate size of:
  - a. Duct.
  - b. Length of runs.
  - c. Elbow reductions.
4. Determine grill openings and restriction.

**ENABLING OBJECTIVES:**

1. Explain the relevant safety practices and procedures.
2. Explain importance of duct sizing and design to efficient operation of system.
3. Explain how undersize and oversize ducts are detrimental to overall system performance.
4. Explain how to use duct calculator if volume and velocity are known.

**UNIT: 17 HEAT GAIN, HEAT LOSS AND DUCT DESIGN**

**LEARNING OUTCOME:**

17.3 Compute heat gain for structures.

**TASK:**

17.3.1 Compute heat gain for structures.

**PERFORMANCE STANDARD:**

Heat gain for structure must be accurately calculated.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Blueprints/specifications, heat loss/gain charts

**PERFORMANCE STEPS:**

1. Determine building materials involved.
2. Determine location of structure.
3. Determine temperature difference.
4. Calculate window head load.
5. Determine sun heat lost.

6. Determine heat log.
7. Determine heat sources within structure.
8. Total calculation from above data.

**ENABLING OBJECTIVES:**

1. Define R and U factors.
2. Describe effects of insulation.
3. Describe effects of structure placement.

**UNIT: 17      HEAT GAIN, HEAT LOSS AND DUCT DESIGN**

**LEARNING OUTCOME:**

17.4 Measure air flow through duct system.

**TASK:**

17.4.1 Measure air flow through duct system.

**PERFORMANCE STANDARD:**

Measured results must be within 10% of a predetermined actual value.

**TOOLS, RESOURCES, EQUIPMENT AND SITUATION(S):**

Standard tool kit, velocity meter

**PERFORMANCE STEPS:**

1. Inspect complete system.
2. Locate all ducts, openings and dampers.
3. Check velocities at each outlet.
4. Determine free grill area.
5. Calculate volume of air flow per minute at each outlet.

**ENABLING OBJECTIVES:**

1. Explain the relevant safety practices and procedures.
2. Explain how to use air velocity indicators.
3. Explain how to traverse a register or grill.
4. Explain how to calculate air volume if velocity is known.
5. Explain how to measure static pressure.
6. Explain how to use an incline manometer.

HEATING, AIR CONDITIONING AND REFRIGERATION

Standard Tool Kit

Adjustable wrench  
Adjustable pliers  
Assorted screwdrivers  
Assorted phillip screwdrivers  
Aviation snips  
Box end wrench set  
Center punch  
Claw Hammer  
Diagonal pliers  
Drive socket set (3/8)  
Drive socket set (1/4)  
Electrician plier  
Flaring tool  
Flashlight  
Hammer soft face  
Level  
Long nose plieers  
Oil can  
Open end wrench set  
Pipe wrench  
Plumb line  
Pry bar  
Safety glasses  
Saw, hack  
Set hollow nut drivers  
Set needle files  
Tubing bender spring  
Tubing cutter  
Wire stripper